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PAPERS

ON

RAILWAY AND ELECTRIC COMMUNICATIONS,

RCTIC AND ANTARCTIC EXPLORATIONS,

AND

THE SANITARY MOVEMENT.

Royal Astronomical Society

BY

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CHAMBERS'S

PAPERS FOR THE PEOPLE.

RAILWAY COMMUNICATIONS.

BEFORE the days of Semiramis, whose highways are among the first mentioned in history, or the times when Roman way-wrights constructed thoroughfares as durable as their language, or Onund of Norway earned his title of 'road-maker,' or Macadam proved the virtue of broken granite, mankind could not have failed to perceive that in proportion to the smoothness and levelness of the ground over which they journeyed, so was the speed, ease, and comfort of travelling. 'Make the paths straight,' must have been a precept of peculiar significance in an age when paths were the only routes; and we can easily imagine that the maker of a road would be regarded with not less of reverent gratitude than he who 'digged a well.' Such insight as we get into remote antiquity shews us that the earliest nations—in the 'far east,' and in the countries bordering the Mediterranean—had mastered the rudiments of road-making, and shaped them into a completeness not far removed from science. The Romans, borrowing the idea of paved roads from the Carthaginians, set to work with that practical common sense which characterised them, and constructed roads from their capital city to every quarter of their mighty empire. With them a chief point was to have the roads straight and level; they understood too well the importance and advantage of facile means of transit and communication, and with singular skill and boldness they pierced or excavated hills, built bridges and viaducts, and raised embankments, remarkable alike for their extent and their durability. In Italy alone there were several thousand miles of public highways; of these the 'Queen of Roads,' or 'Appian Way,' 142 miles in length, is the most noteworthy. It was constructed by Appius Claudius 310 years before the birth of Christ; and Procopius, writing in the sixth century, says of it:—'To traverse the Appian Way is a distance of five days' journey for a good walker, and it leads from Rome to Capua; its breadth is such that two chariots may meet upon it and pass each other without interruption; and its magnificence surpasses that of all other roads. For constructing this great work, Appius caused the materials to be fetched from a great distance, so as to have all the stones hard and of the nature of millstones, such as are not to be found in this part of the country. Having ordered this material to be smoothed and polished, the stones were cut in corresponding angles, so as to fit together in joinings without the intervention of copper or any other material to bind them, and in this manner they were so firmly united, that in looking at them one would say they had not been put together by art, but had grown so upon the spot; and notwithstanding the wear of so many ages—being traversed daily by a multitude of vehicles and all sorts of cattle—they still remain unmoved; nor can the least trace of ruin or waste be observed upon these stones, neither do they appear to have lost any of their beautiful polish; and such is the Appian Way.'

Much of this description remains true even at the present day; and the road, after the lapse of more than 2000 years, still presents an instructive model to the modern artificer.

With the exception of the Roman highways, the public thoroughfares in England scarcely deserved the name of roads. During the period of Saxon rule, and down to the Stuarts, they were mere tracks across the country, patched with rude paving in the softer places, and 'very noisome and tedious to travel in, and dangerous to all passengers and carriages,' as declared in the act imposing 'statute labour' for the repair of the highways in the reign of Mary. The labour when performed was capricious, not systematic: people mended such portions as traversed their farms or estates, and left the rest to take care of itself.

The first attempts at real improvement may be considered as dating from the passing of the first turnpike act in 1653, of which the preamble stated that parts of the great north road leading to York and Scotland were 'very ruinous and become almost impassable, insomuch that it is become very dangerous to all his majesty's liege people that pass that way.' In the reign of Charles II. the taking of tolls was first established on a turnpike-road leading from Hertfordshire to the counties of Huntingdon and Cambridge. So slow, however, was the progress of improvement, that the roads throughout the country were but little changed for the better during the next hundred years; many became worse, and some which had been wide were narrowed by encroachments and neglect. According to Stow, wagons were in use on some roads for the conveyance of goods and passengers as early as 1541; but the most of the traffic was carried on by means of pack-horses, which, tethered together in long trains, made their way slowly and painfully along the causeways, and whoever met them was obliged to step off into the mire on either side to get out of their way. 'The people of Kendal,' says Roger North, writing in 1676, 'could write to most trading towns and have answers by the packs—for all is horse-carriage—with returns—time being allowed—as certain as by the post.' In 1609 to send a letter from York to Oxford, and get back an answer, took a whole month, and even after the establishment of the post in 1660 correspondence was but little expedited. The introduction of coaches, asserted a writer of the day, would ruin the country; the wagons mentioned by old Stow were advocated as 'travelling easily, without jolting men's bodies or hurrying them along,' which the obnoxious coaches did, at four miles an hour. In 1673 travellers were kept a week on the road between London and Exeter, the fare being 40s. in summer and 45s. in winter: the same fare was charged from London to Chester or York. In 1678 a six-horse coach took six days to perform the journey from Edinburgh to Glasgow. At the end of the seventeenth century the stage-coach with six horses occupied two days in the journey from London to Cambridge, fifty-seven miles; and fifty years later the journey to Oxford consumed the same time. Travelling by night was first introduced about 1740, not without opposition from those who foresaw ruin in any departure from old practice. Hogarth's picture, 'The Country Inn Yard,' brings before us the ordinary coach of the period. It underwent alterations from time to time as fancy or convenience dictated. In 1750 the 'Alton and Farnham Machine' was started with a wicker-basket slung behind for the outside passengers.

In the present day a man goes to Constantinople and back as an ordinary pleasure-trip calling for no especial remark. Not so a century ago. It was not uncommon at that period for people whose business led them from the Scottish to the English metropolis to make their wills before starting. The journey was indeed a formidable one, as may be gathered from an advertisement in the 'Edinburgh Courant' for 1758, stating that, with God's permission, the coach would 'go in ten days in summer and twelve in winter:' a man may now breakfast in London and sup in Edinburgh, 400 miles distant, without undergoing severe fatigue, or sitting up to a late hour; and if so inclined, may cross over to New York in less time than was formerly consumed between the two cities. In 1765 a 'flying-coach,' drawn by eight horses, travelled from London to Dover in a day, fare 21s.

Arthur Young's experiences during his 'Tour' in 1770 furnish conclusive evidence as to the condition of the roads at a still later date. He was travelling in Lancashire, a county now among those best furnished with railways, and says: 'I know not, in the whole range of language, terms sufficiently expressive to describe this infernal road. To look over a map, and perceive that it is a principal one, not only to some towns, but even whole counties, one would naturally conclude it to be at least decent; but let me most seriously caution all travellers who may accidentally purpose to travel this terrible county to avoid it as they would the devil, for a thousand to one but they break their necks or their limbs by overthrows or breakings-down. They will here meet with ruts, which I actually measured, four feet deep, and floating with mud, only from a wet summer—what, therefore, must it be after a winter? The only mending it receives in places is the tumbling in some loose stones, which serve no other purpose but jolting a carriage in the most intolerable manner. These are not merely opinions, but facts; for I actually passed three carts broken down in these eighteen miles of execrable memory.' This was not the only instance of bad roads that Young met with; he came upon others farther north, and denounces them in language equally emphatic.

On the eve of the nineteenth century travelling was still slow. Mr

Porter states, that he ' well remembers leaving the town of Gosport (in 1798) at one o'clock of the morning in the *Telegraph*, then considered a fast coach, and arriving at the Golden Cross, Charing-Cross, at eight in the evening; thus occupying nineteen hours in travelling eighty miles, being at the rate of rather more than four miles an hour.'

The time, however, had come for a change; and Telford and Macadam, by their improvements in road-making, prepared the way for more rapid locomotion. The insurrections in Scotland in '15 and '45 led to the formation of numerous roads which penetrated the wildest districts of the Highlands, extending altogether to nearly 1000 miles in length. In these, real principles of construction were acted on, and the system of maintenance developed which gave to us the best roads in the world. In 1815 Telford commenced that grand memorial of his ability—the Holyhead Road; a work that may safely be contrasted with the most famous highways of antiquity, regard being had to smoothness of motion; and though no longer required for the service of the mail, its preservation will, we hope, be diligently cared for by those to whose charge it is intrusted. The establishment of this road effected an important change in our communication with Ireland. ' Previous to 1815, the sailing-packets which plied between Dublin and Holyhead were often tossed for several days in a stormy sea; and when the passengers had completed their miserable voyage, they were landed upon rugged, unprotected rocks, from whence they proceeded by miserable tracts of road, composed of a succession of circuitous and craggy inequalities, for twenty-five miles, across the Island of Anglesey to the Menai Strait—a troublesome and dangerous tidal ferry, over which the mail and other coaches could not be passed in boisterous weather.' Telford carried his road across this strait by means of the famous suspension-bridge which was opened in January 1826, the first stone having been laid in August 1819. It is 1710 feet long, contains 4,373,282 lbs. of iron, or 2186 tons, and cost, with the approaches, £120,000.

The prime object kept in view was to diminish friction, to render draught as easy as possible, and these desiderata were attained. Macadam, about 1816, began to shew that to spread a layer of broken granite over the natural soil, properly prepared and levelled, was the best mode of forming a permanent and serviceable road; and his principles were actively reduced to practice in nearly all parts of the kingdom. The impulse once given, further improvements were continually sought after, and the result was a system of highways, of hard granite roads, as near perfection as mechanical and engineering science could make them. In some places ' granite tracks,' or ' stone tramways,' were laid down, and wherever tried, the result proved in favour of facility of transit. They had long been in use in the streets of Milan; and on Dartmoor a stone trackway was laid for twenty miles, from the quarries to Plymouth. A granite line was also laid from London towards the East India Docks along the Commercial Road; the Forth and Clyde Canal Company made use of iron for a similar purpose; and slate was employed in other quarters, but there was no difference in the results. One horse on the level track could do as much work as four on a common road. The advantage gained was so striking, that a proposal was made to lay granite tracks on the slopes of all the highways in the kingdom, as a certain remedy against the difficulty of ascending them.

In 1840 the total length of turnpike-roads in England and Wales was about 25,000 miles, which had been kept up during the preceding five years at an annual cost of £989,545, or £45 per mile—£36 having been expended in the usual repairs, and £9 on improvements. In addition to these items, the charge for management was nearly £6, also yearly. There were 1116 trusts, 7796 toll-gates and side-bars, and 1300 surveyors. Besides the turnpikes, the extent of other highways, 'parish roads,' was nearly 105,000 miles, maintained at a cost of £11, 3s. per mile yearly.

It was along the chief of these thoroughfares that, up to a recent period, travelling by mail or stage coach was prosecuted with such spirit and regularity as to make the roads a scene of continued animation and excitement. In 1837 licences were granted to 3026 stage-coaches, of which 1507 went to or from London, besides 103 mail-coaches. The number of passengers per year about the period in question has been estimated at 2,000,000. The conveyance of these gave movement to a system of traffic unequalled in any part of the world. In no other country was there such promptitude, such celerity of transit; and in fine weather there was real enjoyment in sitting behind the four spirited horses, which, in their compact and well-kept harness, trotted along the roads at a speed varying from seven to ten miles an hour: and for the leisurely traveller the top of a stage-coach presented advantages for viewing scenery which constitute no part of railway accommodation. There was time to discuss the merits of a ruin or a landscape; the appearance and disappearance of one and the other were not then, as now, simultaneous; and conversation could be carried on with a chance of its being heard. Then there was variety in the road itself: now traversing a well-cultivated vale, curving in and out among pastures and corn-fields, at times pleasantly overshadowed by trees; anon rising over a hill, descending into a valley, skirting or crossing a running stream, penetrating at times the most picturesque parts of the land; going through—not past—towns and villages, where people ran to their doors and windows to see the vehicle speed by, and gazed after it with a feeling of pride as long as it remained in view. The traveller then could make himself acquainted with much that was interesting along his line of route, and carry away a definite impression of the scenes which had passed before his eyes.

But there were drawbacks: exposure to wet or inclement weather; the rapacity of innkeepers who purveyed for travellers; that of their servants; and the fees to coachmen and guards, exercised and levied without compunction, and often with incivility; oppressive to all compelled to submit thereto, but more especially to persons of slender means.

And further: how few of the latter class could afford to travel by stage-coach. The broad-wheeled wagon, creeping on at the snail's pace of three miles an hour, or the canal-boat, oftentimes as slow, was their only resource. In either of these the journey from London to Manchester occupied a week; and yet, with all their tedium and misery, they were much more resorted to by respectable people of scanty means than is commonly known or believed in the present day.

But what travelling was ten years ago is, and becomes more and more, matter of history. Except in little-frequented parts of the country stage-coaches and wagons have disappeared. Having superseded less perfect machinery, they in turn were set aside by a power more in accordance with the aims and requirements of the age.

From the roads of the past we turn to the roads of the present. What was the origin of the latter? According to certain writers we should find it by a study of the ancient Egyptian hieroglyphs. Something, however, more to the purpose than hieroglyphs occurs in Roger North's book, already quoted: 'Another remarkable thing,' says Roger, referring to the neighbourhood of Newcastle-on-Tyne, 'is their *way-leaves;* for when men have pieces of ground between the colliery and the river they sell leave to lead coals over their ground; and so dear that the owner of a rood of ground will expect £20 per annum for this leave. The manner of the carriage is by laying rails of timber from the colliery down to the river exactly straight and parallel, and bulky carts are made with four rowlets fitting these rails, whereby the carriage is so easy that one horse will draw down four or five chaldron of coals, and is an immense benefit to the coal-merchants.' This account, as is obvious, refers to a mode of transport already established, and we may believe that similar contrivances would sooner or later be made available in other districts; but we meet with no subsequent instance until 1738, when a railway was laid down from Cockenzie to the coal-pits of Tranent, across the ground on which, some years later, the Highlanders put General Cope to flight, and won the famous battle of Prestonpans. A portion of the line, which may still be traced, was selected as a position for the English cannon. About the same time iron trams were laid down at the Whitehaven collieries. The practice had been, as described by Roger North, to make the rails of wood, and fix them parallel on cross-pieces called sleepers, embedded in the earth. Thin plates of iron were sometimes nailed on to protect those parts most exposed to wear—a precaution which could scarcely have failed to suggest the idea of rails made entirely of iron. These were first introduced at Coalbrookdale, where, in order to keep the furnaces at work during a slack season, a number of bars five feet long, four inches wide, and one and a half inches thick, were cast to be used as rails instead of wood, with the intention of taking them up for sale in case of a sudden demand.

The difficulty of keeping the wheels from slipping off was urged as an objection against the use of these rails, and obviated some years afterwards, in 1776, by casting rails with an upright flange or guide at one side. These being nailed to wooden sleepers, or, as subsequently, to blocks of stone, the two flanges kept the wheels in place, and kept the wagons from running off the track. The form, however, presented certain inconveniences: dirt accumulated in the angle, and 'edge rails' were substituted, which, with modifications, have ever since remained in use. Those laid down at Lord Penrhyn's quarries were oval in form, with the narrow edge upwards, in lengths of four and a half feet, and kept in place by a solid dovetail block cast on the lower edge, and fitted into an iron sleeper underneath. A flange on either side of the tire prevented any deviation of the wheels; and 'the saving of power was such, that two horses regularly drew a train of twenty-four wagons, each containing about a ton; and ten horses were found sufficient to conduct a traffic which had, on a common road, required 400.'

Another form of rail, in section resembling a T, came into use in the northern mining districts. The descending portion was cast with a gradual sweep — technically, 'fish-bellied'— from end to end, to give strength between the bearings. With this was first used the 'chair'— a supporter made of cast-iron, which, being fixed to the sleepers, received and held each lap-joint of the rails. The wheels were kept from running off by a flange on the inner edge of the tire, while the shape of the rail was such as to prevent any lodgment of dirt on the surface. But in all these rails there was one essential defect — their liability to break; a defect that still remained, notwithstanding the attempts to overcome it by increasing the weight of the casting; and a fatal one, had wrought-iron not been available. Rails of this material were laid down in 1808, but proved unsuitable, owing to their square form, the only one in which they could then be manufactured; and it was not until 1820, when Mr Birkenshaw produced rails by a process of rolling—a species of wire-drawing on a stupendous scale—that the difficulty was overcome. Since then the texture of rails has been as remarkable for toughness and elasticity as it was formerly for rigidity and brittleness.

Gradually iron roads grew into use in coal-fields and the mineral districts in the northern and midland counties; and by the close of the tenth year of the present century there were more than 150 miles in South Wales. The first well-ascertained attempt to take a systematic commercial view of their utility was made in 1800, by Dr James Anderson, in a periodical entitled 'Recreations in Agriculture.' He proposed to construct railways by the side of the turnpike-roads, so as to follow the ordinary levels and lines of traffic: to commence with the highway from London to Bath. Where the road ascended a hill, the level was to be sought by going round its base, constructing a viaduct or piercing a tunnel; and so carefully are these contingencies discussed, that, with the exception of horses being the moving power, the doctor's plans and arguments might be almost literally adopted in a railway prospectus of the present day. One point particularly insisted on was, that the lines should be managed by government commissioners, not by companies, who would unite monopoly with speculation; and should 'be kept open and patent to all alike who shall choose to employ them, as the king's highway, under such regulations as it shall be found necessary to subject them by law.' No immediate result followed the publication of these views; no one had then thought of railways independent of other thoroughfares, and to border the latter by iron routes was a scheme too impracticable to be entertained.

Two years later, in March 1802, a communication from Mr R. L. Edgeworth appeared in 'Nicholson's Journal,' calling attention to the same subject. To quote the writer's words, he had many years before 'formed the project of laying iron railways for baggage-wagons on the great roads of England,' but having been met by numerous and powerful objections, he had despaired of success. Among these was urged the first cost, and the continual charge for repairs. To obviate the latter, he proposed, instead of an enormous load in one car, to divide the burden among several smaller cars, whereby the wear of the rails would be materially diminished. Models of these cars had been presented to the Society of Arts in 1768, and their inventor rewarded with a gold medal. In 1788 he made four other carriages, with cast-iron wheels working on friction rollers, and used them for some time on a wooden railway to convey lime for agricultural purposes.

To test the merits of his plan, Edgeworth suggested that four lines of railway might be laid on ten or twelve miles of one of the great roads leading from the metropolis. The rails were to be made hollow from the bottom upwards, for strength and to save expense; broad at bottom, and rounded at the top, to prevent the lodgment of dirt and dust; and fixed to sleepers of stone, so that their upper surface should stand about four inches above the road. On these should run light wagons, each containing not more than one ton and a half weight. The two inner tracks were to be for goods, the two outer ones for passenger-carriages, to travel in either direction, and when they met, turn off by sidings to the wagon-way. To obviate all difficulty with respect to the wheels of public or private vehicles, they were to be placed on 'cradles or platforms,' fitted and constructed to run on the rails. The horses that brought the carriage would drag it on to the cradle, or truck, as it would now be called, and, descending at the opposite end, draw it along the line—stage-coaches, six miles an hour, with one horse; hackney-coaches, eight miles; and with the greatest ease and safety, by night as well as by day.

Hills were to be avoided by making a circuit; but a perfect level was not absolutely insisted on: no insurmountable objection existed to 'a rise of one foot in ten.' Another part of the plan was the employment of steam-power with stationary engines, with which it would be 'not impossible, by *slight circulating chains*, like those of a jack running upon rollers, to communicate motion between small steam-engines, placed at a considerable distance from each other; to these chains carriages might be connected at will, and, when necessary, they might instantaneously be detached.'

There is yet another name connected with the development of our railway system which must not be passed over—that of Thomas Gray, a native of Leeds. He was in Belgium in 1816, when, hearing that a canal had been projected to connect the coal-field of that country with the frontier of Holland, he very earnestly recommended to Mr Cockerill, with whom he was acquainted, the making of a railway instead. His mind had been for some time directed to the subject; and in 1818 he shewed to his friends manuscript 'Observations on a Railroad for the whole of Europe,' and soon after returned to England for the purpose of making his schemes public. In 1820 he published a seven-and-sixpenny octavo, which went through five editions in five years, entitled 'Observations on a General Iron Railway, or Land Steam Conveyance, to Supersede the Necessity of Horses in all Public Vehicles: shewing its vast Superiority in every Respect over the present Pitiful Methods of Conveyance by Turnpike-Roads and Canals.' In this work, among advantages to result from the new system, Gray shewed that fish, vegetables, agricultural and other perishable produce might be rapidly carried from place to place; that two post deliveries in the day would be feasible; and that insurance companies would be able to promote their own interests by keeping railway fire-engines, ready to be transported to the scene of a conflagration at a moment's warning.

The cost of construction Gray calculated at £12,000 a mile. He was decidedly in favour of direct lines by the shortest course. His plan included a trunk-line straight from London to Plymouth and Falmouth, minor lines to Portsmouth, Bristol, Dover, and Harwich, with an offset from the latter to Norwich; a trunk-line also from London to Birmingham and Holyhead, another to Edinburgh by Nottingham and Leeds, and secondary lines from Liverpool to Scarborough, from Birmingham to Norwich; in short, his system, remarkable for its simplicity, comprehended all the important towns of the kingdom, and in many respects is preferable to that which now prevails. His plan for Ireland had a grand trunk-line from Dublin to Derry, another to Kinsale, and by lesser lines ramifying from these he connected all the chief towns of the island with the capital.

Whatever effect Gray's persevering labours may have had in directing attention to the subject of railways, in suggesting views to others, he himself gained neither reward nor honour. His late years were passed in obscurity as a dealer in glass on commission at Exeter, in which city he died in October 1848, at the age of sixty-one. He deserves not to be forgotten.

These statements embody interesting evidence of the germination of ideas and the growth of intelligence: the time was coming for maturer aims and increased powers of realising them.

The first authorisation of a railway by act of parliament is said to have been that of the Surrey Railway—an iron track laid from Merstham to Wandsworth in 1809; and of a short line from Cheltenham to Gloucester. Both have since become adjuncts or portions of other and grander lines.

In September 1825 a railway was opened which led from the mines near Darlington to the wharfs on the Tees at Stockton—the whole distance about twenty miles—for the transport of coal. At first the wagons were drawn by horses; and such was the effect of easy carriage, that the price of coal at Stockton fell from 18s. to 8s. 6d. per ton; lead was carried from the interior to the ships at greatly reduced rates; and a brisk trade in lime sprung up which had not before existed. Shortly after the opening two coaches were placed on the line for the conveyance of passengers—large, roomy vehicles, to carry twenty-six persons as a regular load, and in extraordinary cases half as many more, an addition which in no way interfered with the speed of the journey. They had no springs, and were intended to run backwards or forwards without being turned. A block of wood made to press against the tire of the wheels by means of an iron lever within reach of the driver enabled him to check the motion or stop suddenly when required. Ten miles an hour was the usual speed, and seemed scarcely to require an effort from the single horse that drew the load, so seldom was there any strain on the traces; and the smooth and equable motion of the coach was a constant theme of congratulation among the passengers. The line originally consisted of but a single pair of rails, with sidings at frequent intervals, at which vehicles or coal-trains passed each other. The fare from Stockton to Darlington—twelve miles—was 2s. for the inside and half that sum for the outside. Traffic became so lively between the two towns, owing to the facility of transit, that in the first year the proprietors returned £500. 'An intercourse,' as was said, 'and trade seemed to arise out of nothing, and no one knew how; and altogether the circumstance of bustle and activity which appeared along the line, with crowds of passengers going and returning, formed a matter of surprise to the whole neighbourhood.' Similar results have been observed elsewhere, wherever legitimate enterprise and not wild speculation has been brought into play.

In the following year, two of Stephenson's locomotives were employed in the coal transport on the line in addition to the horses. It was no uncommon sight to see one of these engines drawing behind it a train of loaded wagons, weighing ninety-two tons, at the rate of five miles an hour. In those days steam-whistles had not yet come into use; and the firemen, to give notice of their approach after nightfall, threw up high into the air, from time to time, a shovelful of red-hot cinders, which could be seen at a considerable distance by those moving in the opposite direction. Without a load the speed of the engines was not unfrequently fifteen miles an hour—a most exhilarating rate of travelling, which at that period was regarded as little less than marvellous.

The year 1825 marks one of those periods in history when the speculative mania, always present in a commercial community, and more or less active, suddenly burst into delirium: projects, however visionary, were eagerly taken up; shares in ideal mines were bought and sold with marvellous celerity; and thousands became dupes of their own folly or thirst for gain. Everything was to be done by steam: by means of coal-gas, people were 'to ride among the clouds at the rate of forty miles an hour, and whirl along a turnpike-road at the rate of twelve miles an hour, having relays, at every fifteen miles, of bottled gas instead of relays of horses.' A writer of the day remarks: 'this nondescript gas-breathing animal, something of the velocipede family, is intended to crawl over the ground by protruding from behind it six or eight legs on either side in alternate succession.' And referring to the numerous schemes then put forward for railways, he continues: 'nothing now is heard of but railroads; the daily papers teem with notices of new lines of them in every direction, and pamphlets and paragraphs are thrown before the public eye, recommending nothing short of making them general throughout the kingdom.' All the great towns of the north were to be connected by railways: Liverpool with Birmingham, Birmingham with London, London with Dover. The ironmasters—trade being slack, and having an eye to business—had the credit of fostering the speculative spirit for their own interests. 'All physical obstructions,' as Telford said, 'were forgotten or overlooked amid the splendour of the gigantic undertakings.'

Real enterprise was, however, steadily pursuing its aim amid all the excitement. Application had been made to parliament for leave to lay down a railway from Liverpool to Manchester — a work then become indispensable to those two increasing and important towns. At that period, and for some time afterwards, canal-boats, and slow, heavy road-wagons were the only available means for the transport of heavy goods or bulky merchandise. The charge for conveyance from London to Yorkshire amounted frequently to £13 per ton, and even at this high cost the service was very imperfect. Beneficial as canals had proved they were becoming inadequate to the growing requirements of trade. Besides the road there were two canals for the traffic between Liverpool and Manchester, the distance by the latter fifty-five miles, and the carriage of goods in some instances £2 per ton. Manchester was so entirely dependent on Liverpool for supplies of raw material, and the saving of time in transport so much an object, that any measure for an additional route was more a necessity than a speculation. It was notorious that goods were frequently conveyed from Liverpool to New York in less time than to Manchester. To make a third canal was impossible, as the district afforded no more water than sufficed for the two already existing. A thousand tons of merchandise were sent daily between the two towns, and produced a yearly revenue of £200,000 to the carriers. On one of the canals the profits were so great that the proprietors received the amount of their original outlay every alternate year.

Reasonable compliance with their wishes would have satisfied the merchants, who sought only to secure prompt and certain means of transport, not to depreciate canal property. Failing in their object, a railway, which had from time to time been talked about, was again discussed. The 'Liverpool and Manchester Railway Company' was formed, and their prospectus issued in 1824. In the following year the bill came before parliament, and there encountered all the opposition which selfishness could invent or ignorance employ, as may be seen in the parliamentary records of the session. The bill, however, was successfully carried in 1826.

Some years before the Duke of Bridgewater, on hearing the remark: 'You must be making handsomely out with your canals,' replied, somewhat chafed: 'O yes—they will last my time; but I don't like the look of these tram-roads: there's mischief in them.' The mischief—if such it was—was about to be realised. The duke's agent was conferred with on the subject of the railway, and an offer made him of shares, which he met by the churlish answer: 'All or none.' To us in the present day it may not be uninstructive to consider some of the forms under which the spirit of opposition strove to effect its purpose.

Canal proprietors were among the first to bestir themselves: they consulted Telford 'as to the most advisable manner of protecting their property;' and the enlargement and extension of the Birmingham and Liverpool, and the Ellesmere canals, were recommended by the eminent engineer as a preliminary measure. To understand the value of this recommendation we must remember that at the period in question railways were generally considered as subordinate or accessory to canals—not as a new resource destined to supersede them.

The legislature even was not exempt from incredulity, to choose a mild term. Stephenson's assertion, during his examination before a committee of the House, that it would not be difficult to make a locomotive travel fifteen or twenty miles an hour, provoked one of the members to reply that the engineer could only be fit for a lunatic asylum. If the opposition were to be believed, the laying down of a railway would inevitably reduce the value of land through which it passed, and landholders, by gradual though sure decline, be brought to the verge of ruin. As a million horses would be thrown out of service, no one of course would care about keeping up the breed; and not only were good horses to become as rare as peacocks, but the 8,000,000 acres of land that produced the oats were to return to a state of nature. A Quarterly Reviewer wrote: 'As to those persons who speculate on making railways general throughout the kingdom, and superseding all the canals, all the wagons, mail and stage coaches, post-chaises, and, in short, every other mode of conveyance by land and by water, we deem them and their visionary schemes unworthy of notice. The gross exaggerations of the powers of the locomotive steam-engine, or, to speak in plain English, the *steam-carriage*, may delude for a time, but must end in the mortification of those concerned.' How ridiculous this reads now to us, who see how completely the results are at variance with the confident predictions! and equally ridiculous will our ignorance and prejudice appear to those who come after us.

Parliamentary sanction once obtained, the Liverpool and Manchester Railroad Company set to work upon their novel and important undertaking—novel, inasmuch as its scheme and magnitude exceeded all that had been previously attempted of a similar nature. Stephenson, who had already won a reputation, was appointed engineer, and a chief point determined on was that the line should be as nearly as possible straight between the two towns. In the carrying out of this design the series of 'engineering difficulties' was first encountered, the overcoming of which has called forth an amount of scientific knowledge, of invention, ingenuity, and mechanical hardihood unprecedented in the history of human labour. Hills were to be pierced or cut through, embankments raised, viaducts built, and four miles of watery and spongy bog converted into a hardened road.

The drainage and solidification of this bog—or Chat Moss, its local name—were among the first operations. It was too soft to be walked on with safety, and in some places an iron rod laid on the surface would sink by its own weight. An embankment twenty feet in height was commenced, and had been carried some distance across the treacherous soil, when the whole sunk down and disappeared; and not until many thousand tons of earth had been deposited and swallowed up was a secure foundation obtained. At the softest part, known as the 'flow-moss,' hurdles thickly interwoven with heath were laid down, and upon these the earth and gravel for the permanent way. The successful formation of this part of the line was looked upon at the time as no unworthy triumph over physical obstacles. It was but the precursor of still greater enterprises.

Another great work was the tunnel under Liverpool, forming a direct passage to the docks without interfering with the streets. Its length is 2250 yards—nearly a mile and a half—the width 22 feet, and height 16 feet, and for greater part of the distance it pierces the solid red sandstone rock of the district. It was begun in 1826, and finished in September 1828, at a cost of £34,791. Besides this there is a tunnel of smaller dimensions, 290 yards in length, leading to the passenger-station, situated in the higher parts of Liverpool at some distance from the docks.

A more than ordinary interest attaches to the history of these works, from the fact of their being the first of the kind: suffice it, however, to state, that sixty-three bridges were built at different parts of the line, most of them of stone and brick. Two capacious tunnels were excavated, and six cuttings through elevations, out of which were taken more than 3,000,000 cubic yards of earth, stone, and gravel. These materials were used in the formation of embankments, for bridges, and other masonry. The double line of rails weighed 3847 tons, and the chairs which held them in place 1428 tons; and the total cost amounted to £820,000—four times more than had been estimated.

During the execution of the works a question of considerable importance had to be decided: whether horses, stationary steam-engines, or locomotives, should be the tractive power. A high rate of speed, if not impossible, was, as we have seen, considered unsafe, otherwise the employment of animals would hardly have been thought of. The first two, however, were soon set aside; and early in 1829, when the works of the railway were well advanced, the directors advertised a prize of £500 for the best locomotive engine. The stipulations were, that it should draw at least three times its own weight—the latter limited to six tons—and be supported on springs, and not exceed fifteen feet in height; that it should be worked at a maximum pressure of fifty pounds to the inch, make no smoke, and travel, with its load, not less than ten miles an hour. The appearance of the advertisement elicited afresh the shafts of ridicule, as well as the strictures of practical men. Mr Nicholas Wood, in his 'Treatise on Railroads,' says: 'It is far from my purpose to promulgate to the world that the ridiculous expectations, or rather *professions*, of the *enthusiastic speculatist*, will be realised, or that we shall see engines travelling at the rate of twelve, sixteen, eighteen, or twenty miles an hour. Nothing could do more harm towards their general adoption than the promulgation of such nonsense.'

Having now come to the period when the locomotive engine figures prominently in railway history, we must take a brief survey of the origin and development of this important and interesting invention. Excepting the machines made for Kanghi—to be hereafter mentioned—Leupold's appears to have been the earliest steam-engine applicable to locomotive purposes; but the first practical idea of applying steam-power to wheeled carriages is due to Dr Robison, by whom it was communicated to Watt in 1759. Some time afterwards the latter made a model of a high-pressure locomotive, and described its principle in his fourth patent in 1784, which, among certain improvements, specified 'a portable steam-engine, and machinery for moving wheel-carriages.' Watt, however, had doubts as to the safety of his machine, and mentioned the subject to one of his friends, Murdoch, who three years afterwards constructed a model of a locomotive which proved the correctness of the previous calculations. 'This engine,' we are told, 'was made in 1787, and persons are still alive who saw it in that year drive a small wagon round a room at his house at Redruth, in Cornwall. Among those who saw it was Richard Trevithick, who, in 1802, took out a patent for a similar invention.'

Singularly enough, a similar model was exhibited the same year at the opposite end of the kingdom. Symington's locomotive was then shewn in the house of Mr Gilbert Measom at Edinburgh. He pursued the experiment, and in 1795 worked a steam-engine on a line of turnpike-road in Lanarkshire and the adjoining county. Then followed that by Trevithick and Vivian in 1802, which ran on the Merthyr tram-way, and drew a load of ten tons at the rate of five miles an hour. Slight ridges were left in the edge of the wheels and on the trams, to prevent their slipping round, and to insure a forward movement. That without this precaution there could be adhesion or advance was an idea that long prevailed. The cause of this slipping lay in the construction of the engine, which had but one cylinder, and the crank having to pass two centres during one revolution of the wheel, the consequence was an occasional slow, dragging motion. Trevithick, who was a man of great ability, and one to whom steam-locomotion is much indebted, afterwards made a carriage to run on common roads which combined several of the arrangements now in use. The fire-place was surrounded by water, and the waste steam blown off through the smoke-pipe to produce a draught. The cylinder was placed inside the boiler for economy of heat, and the fore-wheels made to turn by cranks connected with the piston-rod, but with one cylinder only the motion was very irregular. This engine was exhibited on one of the roads in Lambeth in 1806, without, however, exciting more than a temporary interest. Three years previously another locomotive by Trevithick had blown up—an accident which created so much dread of high-pressure steam-carriages that a feeling of alarm arose respecting their use, which in some quarters is not even yet entirely dissipated.

Blenkinsop, of Middleton Colliery, near Leeds, constructed a locomotive in 1811, the wheels of which were cogged and ran in toothed rails; a noisy contrivance, intended to overcome the imaginary difficulty—want of bite—and effectually preventing rapid motion by its enormous friction. The engine had two cylinders, and so far was an improvement on those which preceded it, and laboured along at five miles an hour. The Chapmans came next with a new plan: a chain stretched from one end to the other along the middle of a tram-way was passed once round a wheel fixed beneath the carriage, and this wheel being made to revolve by the action of machinery, its bite on the chain caused the whole to move forwards. This method involved so great an amount of friction that it was abandoned, almost as soon as tried. Brunton followed in 1813 with mechanical legs and feet attached to the rear of his engine, intended by their alternate walking motion to propel it continually onwards, and prevent the slipping of the wheels on the rails. Considerable ingenuity was displayed in this contrivance, which performed well, and in certain cases might be employed with advantage, but was not well adapted to locomotive propulsion. The difficulty against which it was especially applied was soon proved to have no existence.

During the same year Blackett repeated Trevithick's experiments at Wylam, in Northumberland; and the fact was satisfactorily demonstrated that, in ordinary circumstances, and with clean rails, the adhesion between the wheel and the rail was sufficient to cause a progressive motion. It would have been proved long before had the engines and tram-plates been heavier: both were too light; and the slipping so much complained of had been an accidental, not a necessary consequence.

Meantime Stephenson was busy at Killingworth, in another part of Northumberland, making and testing locomotives. In 1814 he verified the experiments of other inventors, and went beyond them all in the perfection and performance of his machinery. He took out patents in the two following years for engines, that with a load of twenty tons, and on smooth rails, would travel five miles an hour, and ten miles without a load. No better result at that time was looked for. The possibility of transporting heavy goods with facility at a slow pace having been demonstrated, all that remained was to make it available.

Before the Liverpool and Manchester Company advertised their prize of £500, they sent a deputation to Killingworth to witness the working of the locomotives, with a view to the employment of a similar power on the line then in progress. Although the rails were not laid with that precision now considered so indispensable, the deputation found that the locomotives had been kept at work with much regularity, drawing heavily-laden trains of wagons from the coal-pits to the ships in the Tyne. They reported in favour of locomotive power, and in accordance with their decision the advertisements appeared.

The 8th of October 1829 was fixed for the trial, and on the appointed day three engines were brought forward to compete for the prize: a competition which involved much more than the winning of £500. Stephenson was there with his *Rocket*, Hackworth with the *Sanspareil*, and Braithwaite and Ericson with the *Novelty*. The test assigned was to run a distance of thirty miles at not less than ten miles an hour, backwards and forwards along a two-mile level near Rainhill, with a load three times the weight of the engine. The *Novelty*, after running twice along the level, was disabled by failure of the boiler-plates, and withdrawn. The *Sanspareil* traversed eight times at a speed of nearly fifteen miles an hour, when it was stopped by derangement of the machinery. The *Rocket* was the only one to stand the test and satisfy the conditions. This engine travelled over the stipulated thirty miles in two hours and seven minutes nearly, with a speed at times of twenty-nine miles an hour, and at the slowest nearly twelve; in the latter case exceeding the advertised maximum, in the former tripling it. Here was a result! An achievement so surprising, so unexpected as to be almost incredible. Was it not a delusion?—had it been really accomplished?—and could it be done again?

The prize of £500 was at once awarded to the makers of the *Rocket*. Their engine was not only remarkable for its speed, but also for the contrivances by which that speed was attained. Most important among them was the introduction of tubes passing from end to end of the boiler—said to have been suggested by Mr Booth, secretary to the company—by means of which so great an additional surface was exposed to the radiant heat of the fire, that steam was generated much more rapidly, and a higher temperature maintained at a smaller expenditure of fuel than usual. The tubular boiler was indeed the grand fact of the experiment. Without tubes steam could never have been produced with the rapidity and heat essential to quick locomotion. In more senses than one the trial of the three locomotives in October 1829 marks an epoch.

By burning coke instead of coal, the stipulated suppression of smoke was effected: the quantity consumed by the *Rocket* during the experiment was half a ton. The coke and water were carried in a tender attached to the engine.

On the 15th of September 1830 the railway was opened. The two great towns, with due regard to the importance of the event, made preparations for it with a spirit and liberality worthy of their wealth and enterprise. Members of the government, and distinguished individuals from various quarters, were invited to be present at the opening. On the memorable day a train was formed of eight locomotives and twenty-eight carriages, in which were seated the eminent visitors and other persons present on the occasion, to the number of 600. The *Northumbrian*, one of the most powerful of the engines, took the lead, followed by the train, which, as it rolled proudly onwards, impressed all beholders with a grand idea of the energies of art, and of the power destined soon afterwards to effect the greatest of civil revolutions. At Parkfield, seventeen miles from Manchester, a halt was made to replenish the water-tanks, when the accident occurred by which Mr Huskisson lost his life, and tempered the triumph by a general sentiment of regret. The proceedings, however, though subdued, were carried out in accordance with the arrangements prescribed.

Business began the next day. The *Northumbrian* drew a train with 130 passengers from Liverpool to Manchester in one hour and fifty minutes; and before the close of the week six trains daily were regularly running on the line. The surprise and excitement already created were further increased when one of the locomotives by itself travelled the thirty-one miles in less than an hour. Of the thirty stage-coaches which had plied between the two towns, all but one went off the road very soon after the opening, and their 500 passengers multiplied at once into 1600.

In December commenced the transport of goods and merchandise, and afforded further cause of astonishment; for a loaded train, weighing eighty tons, was drawn by the *Planet* engine at from twelve to sixteen miles an hour. In February 1831 the *Samson* accomplished a greater feat, having conveyed 164½ tons from Liverpool to Manchester in two hours and a half, including stoppages—as much work as could have been performed by seventy horses.

There are many now in their manhood who will remember the wonder and excitement created by these results in all parts of the kingdom. The facts could not be disputed. Neither the laws of nature nor science could be brought to accord with the views of those who saw in the new agencies the elements of downfall and decay. Even the company had gone surprisingly astray in their calculations. Believing that the major part of their business and of their revenue would be derived from the transport of heavy goods, they had set down £20,000 a year only as the estimated return from passenger traffic; and scarcely a week had passed before they became aware of the fact, as agreeable as it was unexpected, that passengers brought the greatest return. The whole number conveyed from the time of opening to the end of the year—three months and a half—was more than 71,000.

From all accounts of locomotives it appears that some of the first constructed were intended to run on common roads. According to Du Halde, the history of such carriages begins at an earlier date than is commonly supposed. He relates that, about the year 1700, the Jesuit missionaries in China invented certain mechanical curiosities for the entertainment of the emperor Kanghi. 'They caused a wagon to be made of light wood, about two feet long, in the middle whereof they placed a brazed vessel full of live coals, and upon them an eolipile, the wind of which issued through a little pipe upon a sort of wheel made like the sail of a windmill. This little wheel turned another with an axletree, and by that means the wagon was set a-running for two hours together; but for fear there should not be room enough for it to proceed constantly forwards, it was contrived to move circularly in the following manner:—To the axletree of the two hind-wheels was fixed a small beam, and at the end of this beam another axletree passed through the stock of another wheel, somewhat larger than the rest; and accordingly as this wheel was nearer or farther from the wagon it described a greater or lesser circle. The same contrivance was likewise applied to a little ship with four wheels: the eolipile was hidden in the middle of the ship, and the wind issuing out of the two small pipes filled the little sails and made them turn around a long time. The artifice being concealed, there was nothing heard but a noise like wind, or that which water makes about a vessel.'

Some years later Cugnot produced a steam-carriage at Paris, which, after having proved its inefficiency, was laid aside, and is still to be seen in the Conservatoire des Arts et Métiers. In 1772, the American, Oliver Evans, began to experiment on steam with a view towards employing it as a substitute for animal power. 'In the year 1786 he petitioned the legislature of Pennsylvania for the exclusive right to use his improvements in mills and his steam-wagons in that state. The committee to whom the petition was referred heard him very patiently while he described the mill improvements, but his representations concerning steam-wagons made them think him insane:' his petition as regarded the wagons was refused. Evans foresaw that steam would one day be the prime agent of locomotion, and he frequently declared that the time would come when travellers would be conveyed on good turnpike-roads at the rate of fifteen miles an hour, or 300 miles a day, by a contrivance similar to his own. Within the next thirty years numerous attempts were made by inventors in this country to employ steam-power on common roads. The prospect appeared promising; for if once successful, there were excellent highways already prepared on which to conduct a traffic, thereby saving all the outlay required for a perfectly level or independent route. Trevithick's experiments have already been mentioned. Griffith brought out a steam-carriage in 1821, portions of which were the invention of a foreigner. Another by Gordon, in 1822, was contrived to work inside a large iron drum, as a squirrel runs in his revolving cage; with what advantage does not appear. Gurney, reputed as the most persevering of all the experimentalists, next took up the subject, and produced an engine ingeniously constructed, and in which the objection as to noise was to a great extent overcome. Instead of allowing the waste steam to be blown off by puffs, as in the usual way, it was made to enter a chamber, from which, by a special contrivance, it issued with a steady and noiseless current, and created a draught as it passed to the funnel. In 1826 it performed the journey from London to Bath, and in a manner that indicated how much remained to be improved before the sanguine hopes of the inventor could be realised. Other competitors were in the field—Dance, Macerone, Church, and Hancock, among the most prominent: Gurney, persevering, had in 1831 three steam-carriages running for the conveyance of passengers on the road from Cheltenham to Gloucester. Four trips a day were kept up from February to June, at a greater rate of speed than that of the stage-coaches on the same nine miles of road, and at half their fares. In that time 3000 passengers had been conveyed, with an expenditure of £50 for coke, besides high wages to the engineer and his attendants. The success was such as might have led to a permanent undertaking, had not a formidable opposition been organised. Injurious reports were industriously circulated, and all travellers cautioned against trusting themselves to the dangers of steam; and, for more effectual hinderance, a portion of the road was covered to a depth of eighteen inches with loose stones. In attempting to pass this impediment the working-axle of the engine was broken, which for the time put a stop to steam-communication between Cheltenham and Gloucester. Before any steps could be taken to renew it, a number of turnpike acts had been hurried through parliament, by which excessive tolls—from 40s. to 68s.—were imposed on carriages driven by steam machinery, to be paid at each time of passing. These measures, while they checked the operations of the engineers, proved that legislators could overlook the fact, that roads are more injured by horses' feet than by wheels.

In the same year Hancock started a steam-carriage—*The Infant*—to run between Stratford and London, which excited much attention from the compactness and efficiency of its arrangements, and led to attempts in other quarters. Sanguine projectors promised lines of steam-omnibuses for all the great thoroughfares of London and the suburban districts, and coaches for Bristol and Birmingham. Meantime Gurney had petitioned parliament: a committee appointed to consider the subject of his memorial reported in favour of the introduction of steam-carriages on turnpike-roads; the increasing enthusiasm, however, for railways at that period diverted inventive enterprise into another direction, besides which the indiscreet zeal of the advocates of the carriages raised feelings unfavourable to success. To talk of travelling twenty-five miles an hour on a turnpike-road, with all its windings, all its regular and accidental traffic, was probably a mistake: half that speed would be the highest compatible with public safety. It is still a question whether highway locomotives might not be employed with profit and convenience between railways and towns lying a short distance off the line.

The history of an invention, like that of an individual, interests us more in its account of early struggles than of ultimate triumph. We dwell with varied emotions on the first attempt, the appearance of the germ, its growth and upspringing. Errors, disappointments, and difficulties often make us tremble for the result; but the error is avoided, the disappointment gives vigour to a new effort, the difficulty becomes an impulse to more strenuous exertion—and success crowns alike the endeavour and the aspiration. After that, though we may be gratified or astonished at the results, we feel that the secret charm of the interest has ceased. The lingering doubt, the quick hope, are no longer there to arouse, and animate us in our own career. The race commanded our whole sympathies, and called out our latent energies. The arrival at the winning-post brings a flash of exultation—a brief thrill, which puts an end to the generous hope, the eager joy, of the earlier career.

We come now to that period in the history of railways when attempt passed into the fulness of enterprise. The success of the Liverpool and Manchester Railway revived some of the projects of the year 1825, and in 1830 two schemes which had been put forth for a railway from London to Birmingham were combined, the object being four lines of rail throughout the whole distance. Had this original intention been carried into effect, there is great reason to believe that the advantages which it offered would have more than compensated for the additional cost involved in such a width of roadway. Ultimately, however, a double line of rails was decided on, and a bill brought before parliament and read a first time in February 1832. Being referred to a committee, it met with a most searching investigation and strenuous opposition, notwithstanding which it passed the Commons, but was thrown out by the Lords. Two noblemen, whose estates lay near Watford, exerted all their powerful influence against it; and the company, for their unsuccessful attempt, were put to an expense of £32,000. They carried their point in the next session at a total cost of £72,868, the bill having passed in May 1833. Mr R. Stephenson was engaged as engineer, and very soon eighty miles of the works were in progress.

The original estimated cost of this railway was in round numbers £2,500,000: owing, however, to the unforeseen difficulties, to the rise in the price of iron from £9 to £14 per ton, and the panic in commercial affairs in 1836, the actual cost amounted to £2,000,000 more. The line, 112¼ miles in length, was opened for the entire distance in September 1838. In 1839 the total received for passenger traffic was £608,564; in the first six months of 1851 it amounted to £723,862, besides £453,717 for the transport of coal, live-stock, and merchandise—making a sum of £1,177,579 received in half a year. The working expenses for the same period were £415,420. In 1846 the name of the line was changed to 'London and North-Western,' under which it now includes a group of railways with extensive ramifications—their united capital being at the time £22,989,310. The company own 188 stations; and, including lines leased, or supplied with locomotive power, they work altogether 863¼ miles of rail. According to the published report, the working stock consists of—563 engines; 562 tenders; 1 state-carriage; 555 first-class, mail, and composite carriages; 489 second-class; 345 third-class; 259 horse-boxes; 243 carriage-trucks; 200 guards' brake and parcel-vans; 8052 wagons; 203 sheep-vans; 1155 crib-rails; 5150 sheets; 55 parcel-carts and trucks; 24 travelling post-offices and tenders; and 162 horses.

The Grand Junction line connecting Birmingham with Liverpool is a rare if not the only instance of a great railway having been sanctioned by parliament without opposition. The bill was passed in 1833, and the line opened in 1837. The act for the Eastern Counties line was obtained in 1836; a portion was opened in 1840; as far as Colchester, 51¼ miles, in March 1843; and the line through Cambridge to Brandon in 1845. The act for the London and South-Western passed in 1834—opened May 1840: the South-Eastern in 1836—opened February 1844: the Brighton in 1837—opened 1841. The short line to Blackwall was opened in 1840: the Great Northern, formerly the London and York, in August 1850; it now comprehends, with its loops and branches, 285 miles. According to the act passed in 1844, the line from Chester to Holyhead was to have been carried across the Menai Bridge; this act was amended in the following year. In

May 1846 the first stone of the Britannia Bridge was laid—in March 1850 it was opened for traffic. As is well known, the passage of the strait and of the Conway is effected by means of the famous iron tubes—capacious tunnels placed high in air, and secure under the heaviest trains :—

> 'Structures of more ambitious enterprise
> Than minstrels, in the age of old romance,
> To their own Merlin's magic have ascribed.'

A line from Edinburgh to Dalkeith, worked by horses, was commenced in 1826, and opened in 1831; that to Glasgow in 1842; the other Scottish railways, one of which extends north as far as Aberdeen, are all of more recent construction. The Dublin and Kingstown was the first Irish line, opened in 1834; acts for the others were obtained in 1836 and 1837.

The bill for the Great Western Railway first came before parliament in 1833, in the face of an active opposition which ultimately led to its rejection by the Lords, after an outlay of £30,000 on the part of the promoters of the measure. The seats of learning, Eton and Oxford—behind-hand in knowledge—particularly distinguished themselves in their antagonism. To have a station near the famous grammar-school or the ancient university, with a railway reaching to the metropolis, was to be fatal to the studious and steady habits of boys on the one hand, and of young men on the other; and on this poor assumption the course of a grand ameliorating enterprise was for a time effectually hindered.

Application having been renewed, the bill passed in 1835. The parliamentary proceedings from first to last cost £89,197—a literally wasteful expenditure, and one that involves a permanent tax on the travelling public, in the higher rate of fares which they are made to pay. A portion of the line was opened in 1838; to Bristol in 1841; and to Exeter, 194 miles, in 1845.

It had first been proposed to make the station of the London and Birmingham Company serve also for the Great Western, the first half-dozen miles leading from the metropolis to be common to both; but as the country to be traversed presented favourable levels, Brunel, who had been appointed engineer, recommended the adoption of a broad gauge, or width between the rails of seven feet. With the exception of the Eastern Counties line, where Braithwaite had laid the rails five feet apart, the gauge on the Birmingham, and all the principal lines then undertaken, was four feet eight and a half inches, consequently the idea of using any portion of the line in common had to be given up. The Great Western Company chose an independent station, and sanctioned their engineer's project, which involved a wider roadway, and greater dimensions in all the details and works, than on other lines. The gauge of four feet eight and a half inches was that which—perhaps without any specific reason—had long been used in the mining districts: Stephenson adopted it on the Liverpool and Manchester line, and hence it became the standard for other lines; not that opinion was unanimous in its favour, for the Rennies among others had declared in favour of five feet prior to 1830. The narrow gauge is adopted in France, in the United States, and in Belgium—where, on the line from Ghent to Antwerp, the width is but three feet nine inches. With few exceptions, all the Italian and German lines are also on the narrow gauge: the Basle and Strasburg is six feet three inches; and the Dutch lines are six feet six inches. Five and six feet is the gauge of some of the Irish lines.

Brunel considered that with a seven feet gauge he should be able to insure smooth and steady motion; the bodies of the carriages would be between and not above the wheels, as on the narrow gauge—an arrangement, by the way, not now carried out in practice. Ordinary carriages and other vehicles might be conveyed on low trucks without difficulty, owing to the increased width; and, more than all, the locomotives would be adapted for extraordinary developments of power. The increased expense excited murmurs and an inquiry, but without leading to any alteration. On the Eastern Counties line the directors had found it necessary to abandon the five feet gauge for the narrower one universally adopted on lines with which they came into connection. In effecting the alteration they took up and relaid eighty-six miles of rails.

When in 1844 the line from Bristol to Gloucester was opened, which, by the influence of the Great Western Company, had been laid on the broad gauge, all the practical inconveniences of 'break of gauge' were immediately felt. Travellers from Bristol or Birmingham, compelled to pass with all their baggage from one set of carriages to another, were not slow to murmur and threaten; and at the latter-mentioned town a public meeting was held to remonstrate against the continuance of the interruption.

This may be considered as the first move in the 'battle of the gauges,' which has been fought with the spirit and pertinacity ever excited by a desire for gain, or the hope of circumventing an opponent. The territory lying between the two rival lines—the Great Western and the North-Western—was the prize contended for. Whichever obtained possession would be able to keep the other from any share in the traffic. Active measures were taken on both sides; and troops of engineers, surveyors, and levellers, taking possession of the ground, tasked themselves to the utmost to prepare their plans and specifications for the memorable 30th of November 1845 — that Sunday, before midnight of which the 'standing orders' required the documents to be lodged at the Board of Trade. Such a running, riding, driving and steaming, contrivance and circumvention, then took place throughout the length and breadth of the land as were never before heard of. As the evening closed in, messenger after messenger rushed into Parliament Street at headlong speed, panting with excitement, and delivered his burden of papers and parchments into the custody of the government officials. The stir was universal, for similar documents had to be placed in the hands of every clerk of the peace of every parish across which a railway had been projected—and how few were there that escaped in the mad excitement of the day! More than 1200 companies—one-half having registered their prospectuses—had been started: the capital represented by those registered was £563,203,000.

From 1801 to 1840, 299 railway acts and extensions of acts were passed; the numbers in the following years serve as an index of the speculative spirit of the time. In 1841, 19 were passed; in 1842, 22; in 1843, 24; in 1844, 48; in 1845, 120; in 1846, 272; in 1847, 184; in 1848, 83; in 1849, 35; and in 1850, 36. The London and North-Western shares, in August 1845, were selling at £252; the Great Western, £256; Midland,

£180; and the others in proportion—an extraordinary rise, followed soon afterwards by a fall of from 50 to 300 per cent.

Nearly 600 railway bills came before parliament in 1846. In the same session the gauge-question was discussed, and the Great Western projects, after rigorous investigation, were authorised under certain conditions: at the same time a commission of scientific individuals was appointed to test the merits of the respective gauges. Many persons will remember the experiments made by Professor Barlow and the astronomer-royal in January 1846—remarkable for the extraordinary velocity at which the trial-trips on broad and narrow lines were made. Their report embraced the whole bearings of the question, the difficulties of break of gauge were fully considered, advantages and disadvantages balanced; and although in some respects the broad gauge was to be preferred, they recommended that as the greater part of England was already laid with the 4 feet 8½ gauge, it alone should be maintained and permitted 'in all public railways now under construction, or hereafter to be constructed in Great Britain.'

The appearance of this report kindled a lively controversy: the Board of Trade did not hold themselves bound by all the recommendations; and permission was eventually given to the Great Western Company to extend their broad gauge to Rugby, to Birmingham, and Wolverhampton; also to the whole south and west of their existing line from London to Bristol and Exeter, and to be confined to those limits. Thus the question was compromised, and scope allowed for an active competition, which still exists between the two companies most interested.

It is not difficult to perceive that railway legislation is yet susceptible of amendment: there is no good reason why enormous expenses should be incurred in carrying a bill through parliament—expenses injurious alike to the companies and the public. The placing of railways under the control of the Board of Trade in 1840 was a step, but not far enough, in the right direction. The Board are empowered to forbid the opening of any line which they may consider unsafe, and to compel such alterations as public safety requires, particularly with respect to bridges, viaducts, or crossings. All disputes between differing companies are to be referred to them, and they can order returns of all accidents that take place, and institute inquiry according to circumstances. Then, in 1844, an act was passed designed to protect the public against the consequences of monopoly on the part of railway companies. By its provisions government was enabled to revise the tolls and charges of any railway of which, twenty-one years after the passing of the act, the profits should exceed 10 per cent., and reduce them to this value. They might also, on giving three months' notice, purchase any railway at a price estimated from the average of the three preceding years; and further, for the protection and benefit of travellers, all companies sanctioned in 1844, or in any subsequent session, were to provide third-class carriages as prescribed by certain regulations:—

'The hour of starting to be subject to the approval of the Board of Trade.

'The speed to be, upon an average, not less than twelve miles an hour for the whole distance travelled, including stoppages.

'The train shall, if required, take up and set down passengers at every passenger-station.

'The carriages shall be provided with seats, and protected from the weather in a manner satisfactory to the Board of Trade.

'The fare of each passenger shall not exceed one penny a mile.

'Each passenger shall be allowed to take half a hundredweight of luggage, not being merchandise or other articles carried for hire or profit, without extra charge; and any excess of luggage is to be charged by weight, at the lowest rate charged for passengers' luggage by other trains.

'Children under three years of age, accompanying passengers, are to be taken without charge; and under twelve years of age, at half-price.'

In certain cases the companies have been allowed to change some of these regulations for others, but not less suitable or efficient: as regards the fare the statute is imperative; it is not to exceed 1d. a mile, though it may be lower. No toll is levied on third-class fares, but on all other sums received for passenger-traffic 5 per cent. must be paid to government. The act also regulates the charges for the conveyance of troops, police, and persons employed in the public service: commissioned officers may travel in first-class carriages at a fare not exceeding 2d. a mile; soldiers and policemen at 1d. a mile in third-class carriages; and stores are to be conveyed at 2d. a ton per mile. All companies are further bound to permit the erection of an electric telegraph along their lines if required for Her Majesty's service; and compensation for loss of life or injury while travelling is substituted for the law of deodand which formerly prevailed. And last, paid inspectors and commissioners are appointed to see that the provisions of the act are duly enforced and obeyed.

Had it not been for the regulations affecting third-class passengers, that large section of the travelling community would, we may believe, have found themselves still riding in open boxes, exposed to all weather, obliged to start at hours expressly chosen for their inconvenience, and delayed on the journey as might suit the humour of their carriers. Even at the present time there is too much disposition to shew small consideration to those who pay but a penny a mile. At many stations the second and third class passengers are always drawn beyond the shelter of the roof before the train stops whatever be the weather; and the 'through' transit is often rendered difficult to those who pay the lowest fares. On some lines of railway—several even which have termini in London—open uncovered boxes are still used as third-class carriages. These are unobjectionable in very fine warm weather, but in winter, or during cold rains or winds, an unsheltered journey becomes most painfully distressing. On one or two other main lines leading northwards from the metropolis the third-class carriages are bad, but the second class are worse; too low to allow passengers to sit upright with their hats on, and with a single opening of fifteen or eighteen inches square on each side for all outlook and ventilation, as though not to see the country made travelling more agreeable. This is short-sighted and suicidal policy. Money, in itself, is not the only thing worth striving for; or if it be, it profits best those who exercise a generous policy. Competition will do much towards amending these grievances, and already it is felt that the best accommodation attracts most traffic. The Great Northern has set a praiseworthy example of what can be done with clean, convenient, and cheerful carriages, though there is still room for improvement. Punctuality, and the minimum of annoyance compatible with a train in motion, are safer resources than a reputation for the fastest travelling. In leaving this part of the subject we cannot refrain from an emphatic protest against the now prevalent practice of disfiguring the roofs and sides of carriages with advertising show-bills: it ought not to be tolerated for a single day.

The idea of propelling carriages by atmospheric pressure was first suggested by Vallance at Brighton in 1824. A tunnel was to be made, air-tight, and large enough to receive carriages, which, on the exhaustion of the tube by means of steam-power and the admission of air at one end, were to move rapidly under the influence of the pressure. On this plan, whatever the length of the journey, passengers would have had to travel in the dark—a fatal objection. It was afterwards shewn that small continuous tubes worked on the same principle might be made available for the rapid transmission of letters. Next Medhurst, in 1827, and Pinkus, in 1834, proposed improvements. In 1839–40 Clegg and Samuda laid down a mile of atmospheric railway, as a working-model, at Wormwood Scrubs, near Paddington. A nine-inch iron tube was fixed between the rails, having on its upper side a continuous longitudinal valve. A piston working within the tube was connected with the carriage by a bar passing through the valve, and on the admission of air, after exhaustion, travelled forwards with a load of nine tons at thirty miles an hour. The valve being made with an elastic hinge opened readily as the bar advanced, and closed again immediately behind it, and was kept air-tight by a composition of oil and tallow. About the same time Roberts proposed to establish an atmospheric railway across Dartmoor—the tube to be exhausted by water-power. A committee of the House sat to inquire into the merits of Samuda's project—reported favourably, and acts were granted. A line of nearly two miles from Dalkey to Kingstown, in extension of the Dublin and Kingstown line, was constructed in 1843, passing through an 'awkward' district, with sharp curves, and slopes in places of 1 in 50, circumstances to which the atmospheric system is especially applicable. This is still worked at a speed of from thirty to forty miles an hour; but the other attempts made to establish a similar system on the London and Croydon, and on the South Devon lines, failed entirely—chiefly from imperfection in the valve, and difficulty in stopping where required. A contrivance of racks and wheels in place of the continuous valve was proposed by Pilbrow in 1844; and later, a new form of valve by Hallette—two small inflated flexible tubes which, acting as closed lips, would allow of the passage of the piston and at the same time exclude the air. And thus the question as to whether atmospheric is preferable to locomotive power remains unsettled.

The outburst of railway enterprise in England after 1830 excited a similar spirit in the United States. A short line of four miles from the stone-quarries at Quincy to Boston had been constructed in 1827, and in 1829 several miles of the Baltimore and Ohio Railway were completed. These, as well as some other lines projected and laid down about the same time in the coal-fields of Pennsylvania, were worked by horses. It appears, however, that locomotive power was first introduced at Lackawannack, in 1828, on the line which connected the Delaware and Hudson canals.

In 1830, W. C. Redfield proposed the construction of a 'great western railway,' from the Hudson to the Mississippi river, a distance of 1000 miles. This was a magnificent project for that day, and has since been realised, though not in its integrity, by a series of lines stretching across the whole region. The Albany and Schenectady line, sixteen miles in length, was the first made in the state of New York; it was opened in 1833 with locomotive power. There are now in the same state nearly 1500 miles of railway. The whole country is traversed by railways in every direction; their total length at the end of 1850 was 8797 miles, and their cost 286,455,078 dollars, somewhat more than £57,000,000 sterling. The extent to be in operation by the close of the present year has been estimated at 10,000 miles.

A railway convention, attended by 465 delegates, was held at St Louis in October 1849, to discuss the preliminaries of a great trunk-line from the Mississippi to California. This project has since been put forward in another form by Mr Whitney: he undertakes, if Congress will grant a sufficient breadth of land along the whole route, to lay down the line, ten miles at a time, with funds raised by the sale of the land on either side. This is a grand scheme, but it is hardly to be expected that American enterprise will stop short of locomotives across the Rocky Mountains. Meantime the Mormons, prior to building their temple, have commenced a wooden railway, to cross their territory from the Salt Lake to the hill country and to the sea-coast.

According to the above statement, American railways have cost about £7000 a mile—less than one-third of the average expense of English lines. This arises from the cheapness of land, a rough and ready system of construction, and the fact that most of the lines have but one pair of rails, and some of these are nothing more than plates of iron nailed down to continuous wooden sleepers. The rate of travelling is about fifteen and seldom exceeds twenty miles an hour, so that the cost for working and maintenance is kept low, and the liability to accident avoided.

In some respects the arrangements and management of American railways are superior to our own. The carriages are from fifty to sixty feet long, resting at each end on a low four-wheeled truck, which, turning on a pivot, admits of sharp curves being passed without danger of 'derailment'—that is, running off the rails. The seats are placed across, on either side of a clear central space; and as the doors are at the end, a passage-way is thus obtained throughout the whole length of a train—an iron footplate serving to bridge over the space between the carriages. There is a positive advantage in this arrangement: the guard may be readily communicated with at any time in case of danger, and passengers, instead of sitting as though packed into a tea-chest, may pass from carriage to carriage, according as they may wish to change their seats, to look for a friend, or discover a conversable companion. A compartment at one end of each carriage is reserved exclusively for the use of women, and is fitted up with washing apparatus and other conveniences. In cold weather the whole vehicle is kept warm by a stove, and lighted always at night by a lamp at each end. The seats are stuffed, and have padded backs, in all carriages alike, there being no distinction of first, second, or third class. The principle in America is to afford the same accommodation to all at the lowest profitable scale of charges; and it has been found that the dividends are greatest on the lines where the fares are lowest. Such arrangements might not be generally acceptable in England; but the experiment would be worth trying, whether light, roomy carriages, of only one class, with stuffed seats and moderate fares, would find favour on the one hand, and bring profit on the other.

Besides the advantages here indicated, the American carriages are but half the weight of those made in this country; consequently the sixty or eighty passengers which each will accommodate are conveyed with economy of locomotive power and almost the minimum of 'dead weight.' It is a common occurrence on the minor lines in England to see a train weighing from twenty to thirty tons set in motion for the transport of one ton or less of passengers. In some quarters a new and lighter style of carriage has been introduced with manifest benefit; by the substitution of iron for wood, weight is diminished without any sacrifice of strength.

There is yet another convenience peculiar to railway travelling in America which we feel bound to notice: the arrangements respecting luggage. The guard receives your trunks, bags, or boxes, attaches to each a numbered zinc label, and for each one gives you a duplicate, and locks the whole in a special compartment. At the journey's end, you choose among the porters of the respective hotels waiting on the platform, hand your zinc labels to one of them, and walk or ride away, with the comfortable assurance that all your luggage will safely follow. Complaints about lost luggage are consequently rare.

It will be said that the throng of passengers and press of business are so much greater in England than America as to prevent any possibility of similar arrangements. Here thousands travel short distances; there hundreds travel long distances. Here from twenty to forty trains a day from a station scarcely satisfy the demand; there four daily trains suffice for the whole traffic. But might we not require that the most efficient and satisfactory arrangements should be formed where there is most work to be done? If we cannot do everything better than all the rest of the world, we ought at least to do as well. We say this knowing that criticism on railway travelling in England is too often received as the mere expression of petulance; that improvement is easier talked of than accomplished; and knowing also that errors are seldom amended unless pointed out.

Railways on the continent may be said to date from 1783, when a line was laid down at the Creusot Foundries, near Mont Cenis: short lines were subsequently brought into operation in other quarters; but it was not until 1835 that the great movement was commenced, in which other countries had led the way, by the authorisation of the line from Paris to St Germains, which was completed and opened towards the close of 1837. In the following year the Orleans line was undertaken by a company, whose resources proving unequal to the task, the government granted them a lease of ninety-nine years, with interest guaranteed at 4 per cent., and by this means the works were finished. Other companies meanwhile were discussing other projects: the line from Paris to Rouen was opened in May 1843, and shortly afterwards extended to Havre. More comprehensive measures followed on the part of the government, by which they proposed to lead railways from the capital to all the frontiers of France, taking the principal towns and cities on the route. There are now 1800 miles finished and in operation, and 1200 more in progress, making with those projected a total of 4000 miles; and before long railway communication will be complete between several points on the English Channel and the Mediterranean at Marseilles, while by another main line Bordeaux and Bayonne will be reached. The cost of the completed lines up to 1850 was £46,204,704 — an amount which, according to the estimates, will be doubled by the time all shall be in operation.

Belgium made preparations for railways in 1834. Though but a small territory, it was so situated that travel-field of Europe, and not 'battle-field,' might in future be its distinguishing appellation. Two main lines were planned—from Ostend to Liege, and from Antwerp to Valenciennes; thus touching the French frontier on one side and the Prussian on the other, and both intersecting at Malines. 'The undertaking,' so reported the minister of public works, 'is regarded by the Belgian government as an establishment which should neither be a burden nor a source of revenue, and requiring merely that it should cover its own expenses, consisting of the charge for maintenance and repairs, with a further sum for the interest and gradual redemption of the invested capital.' This is the principle on which the government has acted—it made the surveys, decided on the best routes, laid down the lines, and now works them at low fares without incurring debts.

Portions of the lines were opened in 1836; and owing to the favourable nature of the country, and the diligence with which the works were conducted, the whole system was complete by 1841. Besides the lines belonging to the government there are two or three undertaken by private companies, of which the Great Luxemburg is the most important: their route is from near Charleroi to Strasburg, a distance of 140 miles. Altogether the length of the Belgian railways will be 457 miles, which, at the average ascertained cost of £18,016 per mile, will comprise a total expense of more than £8,000,000.

Germany followed: the railways of other countries were permitted to cross her frontiers, and soon numerous lines were stretching far and wide throughout the empire. The traveller may now journey by rail from Ostend to the ports in the Baltic—to Posen, Warsaw, or Vienna, or from the Baltic to the Adriatic at Trieste. Once at Ostend, he will find an iron highway to Berlin or Bâle, Prague, Munich, or Pesth, from whence a line will one day be led to Orsova, and eventually on to Constantinople. In short, a glance at the railway map of the continent will serve to shew how town to town and country to country are linked together from one end of Europe to the other; and still new lines are projected, and those in progress completed.

In most respects the railways of the United States have served as models for those of Germany. In either country the natural level of the soil is followed as much as possible, in order to avoid the expense of cuttings, embankments, or viaducts; each finds single lines with sidings, and from four to five trains daily, at a slow rate of speed, sufficient for the traffic; the style of carriage used in the one is found in the other, and in both the scale of fares is low. The number of miles of railway open in Germany is 4500, and nearly as many more are in progress or projected. The average cost has been estimated at £13,000 per mile.

Holstein has its railway; English engineers are at work on the preliminaries of lines in Sweden and Norway; in Russia a vast system has been projected, and in part carried out at the expense of the state. A line of 400 miles is to connect Petersburg with Moscow, and another of 683 miles with Warsaw: both are commenced. From Warsaw to Cracow a line of 168 miles is already opened; and a goods-line of 105 miles, worked by horses, from the Don to the Wolga. The latter was opened in 1846, four years after the first railway decree was issued. There is also a short line extending a few miles from St Petersburg, chiefly for pleasure traffic, besides others near the capital in Southern Russia from Kiew to Odessa, not yet commenced. The journey from St Petersburg to Trieste some years hence will be remarkable for its length, and interesting in the rapid change of latitude which it will effect. Leaving the Russian metropolis shivering under intensest frost, the traveller will find himself in the short space of three days transported to the sunny shores of the Adriatic.

As yet Italy has made but small progress with railways: a line partly opened is being laid from Venice to Milan; another from Turin to Genoa is approaching completion; and a third from Leghorn to Florence, with branches to other towns in Tuscany, make up a system whose further extension will depend as much on enlightened views as on pecuniary resources.

Spain has two railways: one of eighteen miles, from Barcelona to Mataro; another, forty-five miles, from Madrid to Aranjuez. The latter, chiefly promoted by M. Salamanca, was begun in 1846 and finished in February 1851, when it was opened or 'inaugurated' with the ceremony of 'blessing the engines' by the cardinal archbishop of Toledo, in presence of the court, the Cortes, 1000 distinguished attendants on royalty, troops and halberdiers, and three miles of spectators. There are four classes of carriages, the most inferior being without seats, and in which passengers are allowed to carry a burden on their head without additional charge. The fares are about half of those charged in England. Besides these home lines there are forty miles of railway belonging to Spain in the island of Cuba. When we mention further the line from Alexandria to Cairo, and those in the East Indies, for which preparations have been made, and the lines in Canada, all the railways of the world will be included in our brief summary.

The history of railway communications is a vast subject to be treated of within narrow limits. Presenting much to excite our interest in its earlier periods, in its narrative of progress from the germ to the fruit, it astonishes by the record of later results. With a too limited space for the details which these afford, we must content ourselves with such a summing up as may comprehend the more noteworthy among present results.

Year after year since the opening of the Liverpool and Manchester Railway in 1830 has added materially to the resources and capabilities of our railway system. From local it has grown into national importance. British skill and enterprise have formed the fund whence foreign nations drew example and experience, and in numerous instances their material and handiwork. The British system, whatever may be its imperfections, is worked and developed with greater vigour and activity than any other, and remains unparalleled in the multiplied extent of its operations. We have seen what it comprised in 1830 and subsequent years: the last twelvemonth is still more remarkable. According to the Report of the Commissioners of Railways for 1850, the additional lines opened in that year were in England 477 miles; in Scotland, 104; in Ireland, 44—making the total of the United Kingdom 6621 miles, thus distributed:—5312 miles in England and Wales, 951 in Scotland, and 538 in Ireland. Up to December 1850 the lines authorised by parliament comprehended 12,182 miles: 179 miles having been abandoned, there remained 5382 miles unconstructed, and of these about 4000 miles are as yet untouched. The whole number of stations was 2030: the number of persons employed on railways in operation in England, Wales, and Scotland, in June 1850, was 60,325, or 9.56 per mile; on 1564 miles of unfinished lines the number was 58,884, or 68.15 per mile. The number of engines at work was 2436; the miles travelled over 40,161,850, or 110,333 per day; the tons of coke burnt, 627,528, which had been produced from 896,466 tons of coal. The accident returns for the same year shewed that 216 persons had been killed, and 256 injured—chiefly, as was stated, through want of punctuality in the arrival and departure of trains. The whole number of passengers exceeded 60,000,000; and the grand total cost of all the railways amounted to £220,000,000.

The needs and purposes of trade were never so promptly subserved as now, notwithstanding the prophetic warnings to the contrary. The number of horses remains undiminished, and on most of our canals business has increased and not decayed. Are the London markets over-supplied?—straightway the excess is forwarded by rail to Birmingham, Manchester, or other great centres of provincial population; and tons of vegetables, fruit, eggs, poultry, or fish, which in one place would have perished, form an acceptable supply to hundreds of willing customers in another. The produce of remote agricultural districts has now a value altogether unanticipated a few years ago, and nature's redundant bounties are beneficially distributed. The mineral produce of Yorkshire and the midland counties is now poured into new and wider markets; and the inhabitant of London, as well as of other towns, hitherto supplied with fuel at a high cost, now saves one-third in the price of the coals he consumes. And to a still greater extent is social intercourse promoted. Hundreds of thousands who, twenty years since, had scarcely ventured beyond earshot of the bells of their native village, have now travelled to the county town—to London, that cynosure of the rural eye—or have visited all their friends within a hundred miles; while the dwellers in the noisy city, in the busy marts of trade, have traversed the land hither and thither, viewing the wonders of art with enchanted eye, and the wonders of nature with thankful spirit, and have experienced the gladness of feeling which fair landscapes and fresh breezes never fail to inspire. Without railways the Great Exhibition would have been a mere local show: now millions of spectators, gathered from all lands, have seen the marvellous spectacle, and returned to their homes scarcely less astonished at the rapid locomotion of their journey than at the results of collected industry. Without railways, too, postal reform was a bird without wings. What printing did for the grand truths of the fifteenth century was done for brotherhood and commerce by railways in the nineteenth. Unlimited capabilities for the transmission of correspondence are now afforded to the mail service: 347,000,000 letters were conveyed and delivered in 1850—an almost fivefold increase since 1839. With a celerity and regularity not less remarkable than beneficent the orders of government, calls of trade, messages of love and friendship, tidings of joy and sorrow, of all the hopes and aims, doubts and fears, which actuate a family or community, are despatched to every county and to every town and village in the land, verifying on the grandest scale the truth that all is 'toil co-operant to an end.'

Enlarged experience has improved or modified the details of railway construction and management, and has made available many aids and appliances of which the need had not been foreseen. The old 'fish-bellied' rail has been discarded for one straight and heavier; thirty-five pounds to the yard being too light for the increasing weight of traffic, seventy-five pounds to the yard is that now most in use. Taking the miles of railway in round numbers at 7000 miles, the weight of iron laid down in rails alone would thus amount to 3,696,000,000 lbs., or 1,605,357 tons; in the manufacture of which, as well as of the iron chairs, switches, girders, and columns brought into use by railway constructions, thousands of hands have been employed, and the metallic branch of our national industry largely developed. Balks of wood are found preferable to blocks of stone as sleepers; improved chairs and the substitution of hollow-wrought iron wedges for those of compressed wood facilitate the laying, and increase the stability of the rails; and in some instances, said to be successful, the rails are fixed to iron sleepers by a contrivance that dispenses with the use of chairs or other intermediate support. Signals, crossings, turn-tables; all are improved—in most instances substituting the simple for the complex; and where accidents have occurred in their use, the fault lies not with the apparatus, but with those who have charge of it.

Experiment has furnished data on which the frictional and atmospheric resistances to a train in motion may be calculated, and the most economical principles deduced. Many interesting facts have been brought to light illustrative of the laws which regulate weight at high velocities, and of those affecting speed by departure from a true level. The studious mathematician has enabled the engineer to determine beforehand the nature of his constructions, the strength of his boilers, the energies of his steam. Guess-work, in fact, has had to give place to the exactitude of real science.

The chemist, too, has lent his aid. Great expense was formerly incurred in removing at stated intervals the incrustation deposited by the water on the inside of boilers, where its accumulation was a source of positive injury and loss of power. The diffusion of a small quantity of muriate of ammonia with the water was suggested as a remedy, and being tried in an engine on the South-Western Railway, at the end of five weeks, on opening the boiler, not a particle of incrustation appeared, nor was there any deterioration of the metal. The explanation is, that as soon as ebullition commences the ammonia seizes upon the carbonate of lime contained in the water and converts it into carbonate of ammonia, which then escapes with the steam. By this means hundreds of pounds are saved annually in the repairing of boiler-tubes.

To carry passengers without interruption to the farthest point of their journey, irrespective of the lines over which they passed, was a necessity that increased with every increase of the railway system. To meet certain practical difficulties which it involved, the 'clearing system' was adopted by the different companies concerned. This system is one well known to bankers, who use it daily in the settlement of their business transactions with one another. A central 'clearing-house' was established in London, to which a daily account is sent from each of the allied stations—comprehending nearly the whole of those north of London—containing a statement of the number of passengers that travelled through; of parcels received or transmitted; of goods, cattle, private carriages, railway vehicles retained or forwarded—in short, of all details of the traffic. These are classified, and the various debits and credits indicated by columns written in red or black ink, including the proportion of passenger-tax payable to government by each company; and thus the several liabilities having been ascertained, the payment of a few hundreds of pounds in balances, instead of the inter-payment of thousands, serves to settle the whole.

Railway insurance, too, is another result of the railway system: a resource which, if it had been thought of in the days of stage-coaches, would have failed because of the fewness of travellers. For threepence a first-class traveller may insure his life for £1000, for any journey whether long or short; for twopence a second-class traveller is promised £500; and for one penny the third-class traveller gets £200; or smaller sums for injuries which stop short of the destruction of life. Or the whole term of life may be insured by a single payment. Five, twenty-five, or forty-two shillings will respectively secure £100, £500, or £1000 to the insurer, let him travel whenever he may. This subject is well worthy of consideration by travellers, especially those whose means of existence might be stopped or diverted by any sudden casualty.

Stephenson's prize-engine, *The Rocket*, weighed six tons: locomotives now weigh from 30 to 40 tons. In how far this mighty agent of travel has been improved was shewn in the Great Exhibition, where at one side stood a row of ponderous and magnificent locomotives, finished, though so huge, with the precision of a watch, and seeming formidable in their silence. To speak of them in the present tense, *The Liverpool*, exhibited by the North-Western Company, is one of Crampton's patent—that is, with the driving-wheels at the rear instead of at the centre. It weighs 37 tons, and has a heating-surface of 2400 square feet. *The Lord of the Isles*, belonging to the Great Western Company, is a favourable specimen of the ordinary engines used on the broad-gauge line. Its weight is 35 tons, that of the tender when loaded with a ton and a half of coke and 1600 gallons of water, 18 tons—altogether 53 tons. The heating-surface is 1815 feet, with strength sufficient to bear a pressure of 120 lbs. to the inch. This engine is said to have drawn 120 tons at sixty miles an hour; the usual speed is, however, twenty-nine miles an hour with 90 tons, and a consumption of 21 lbs. of coke to the mile.

Besides these, there was a locomotive by Hawthorn, with improved springs, which keep the bearing on the wheels at all times equal, a steam-chamber inside instead of outside the boiler, and considered equal to a speed of eighty miles an hour. There were specimens, too, of light engines and light carriages for branch-lines or light traffic, and not less swift than some of their heavier competitors.

These instances may serve to convey an idea of the capabilities of recently-constructed locomotives; their velocity of at times seventy or eighty miles an hour may be increased when stronger materials or modes of construction shall be discovered. A cannon ball in its swiftest flight travels four times faster only than the seventy-miles-an-hour express train. The phenomena of passing objects observed during such rapid locomotion are most remarkable:—The steam fills and leaves the cylinder twenty times in a second; twenty times in a second the piston advances and returns, and the outblow of steam sounds as a continuous whiz, so inappreciable are the intervals between the rapid strokes. The driving-wheels, eight feet in diameter, revolve five times in a second, and at every beating of a clock the mighty engine dashes over thirty-five yards of ground!

How various and numerous are the sources of the great results which we have been considering! Here an idea, there a conception has been formed; attempt followed, and the failure of one has proved the success of another. Railway bars and telegraph wires are aiding in a great work: out of them grow ever-new endeavours and capabilities; and it would be rash to say where improvement shall stop, or to assume that we have reached perfection, or that knowledge shall not be increased.

Speeding to and fro, the railway train is an agent of good—a representative of great and persevering thought, of earnest skill and hardy enterprise.

In the deep silence of the night, or the calm of a summer noon, the thoughtful listener may fancy the swift breath of the locomotive to be the panting of a time eager for its advent—in haste to open a brighter era. Yet the coming depends on our own advance; and such as we make it will the time ever be:

'For we see that through the ages one increasing purpose runs,
And the thoughts of men are widen'd with the process of the suns.'

[No. 2]

ELECTRIC COMMUNICATIONS.

ONE of the most striking phenomena presented to the mind of the student of Nature, is the principle of unity which pervades all her multiplied workings and productions. To refer to the fact that the past is linked to the present, and the present to the future—that correlations exist between every department of the organic and inorganic worlds—that the connections become clearer the more they are investigated—is to call attention to what are now received as philosophical truisms. The sympathies which filiate through geology to botany, chemistry, magnetism, zoology, and astronomy, are not less admirable when contemplated in their relation to animated creation; and in the universal desire and ability for communication in the latter, we perhaps have their most remarkable display. Naturalists tell us that gnats and several minor members of the insect race possess the power of making their sensations known to their companions equally with the laborious bee or sagacious elephant. Indeed, the endowing with the faculty to communicate appears to be one of the essential aims of nature. And if so, with what is often termed the subordinate or instinctive part of creation, how much more so in regard to man, who claims supremacy over all! Besides the gift of speech, man, by reason of his intelligence, finds means to convey his thoughts to distant places with an energy and comprehensiveness unknown to the quadrupedal tribes, and thus completes the unity which, starting from the inorganic molecule, is finally exemplified in him.

In the world's younger days, and for long afterwards, smoke and flame were the most obvious and available means for communicating signals to long distances. From the beacon-fires of the Scriptural ages to that which flashed from 'Ida's height,' and the stirring night when

> 'From Eddystone to Berwick bounds, from Lynn to Milford Bay,
> The time of slumber was as bright and busy as the day!'

and also to the period of threatened invasion within the memory of many now living, fire has been made a messenger of news. From the lighthouse top it warns and guides the mariner not less surely than the stars of heaven reveal his position on the trackless waters.

Of old, watchmen stood on the hills and cried aloud; trumpeters blew a blast from hill to hill; or legionaries, with elevated flags or spears, sent tidings afar. 'Swift as a post' was not an inappropriate simile even in primeval days: Egypt's learned priesthood knew how to avail themselves of mysterious vocal tubes; the monarchs of Mexico and Peru maintained a corps of runners, who bore despatches to all parts of their empire with singular celerity. Another generation conveyed their wishes in the flashes of mirrors, the pealing of bells, the thunder of cannon, or flight of pigeons. Then came the mail-coach, with its fleet officials and fleeter steeds; to be in turn superseded by that triumph of steam, the locomotive and express train, speeding across a county in shorter time than the mail would have traversed a parish, seeming, in its career of seventy miles an hour, to have reached the limit of human possibility. But a new invention came to light, before which the wildest dreams of romance—the flying horse that carried off Prince Firouz, or Prince Houssain's travelling carpet—seem to become sober realities; and all former methods for the transmission of intelligence have been for ever excelled by the Electric Telegraph. With this man has achieved an entire and absolute unity.

The establishment of a telegraph necessarily involves a certain degree of civilisation—there must be fixed habits and steady policy; and we cannot better appreciate the advantages of the present system than by contrasting it with the past. To do this we need not go back to the time of the Greeks or Romans; our purpose will be effectually answered by a retrospect to the last two centuries. One science or art helps on another: to distinguish objects afar off there must be the possibility of seeing at a distance; and thus the study of optics and the invention of telescopes and reflectors would naturally suggest new applications of utility.

The Marquis of Worcester alludes to a telegraph in his famous 'Century of Inventions.' After him we may place Robert Hooke, one of the most notable philosophers of his age, who, in 1684, presented a paper to the Royal Society, 'Shewing a way how to communicate one's mind at great distances.' He had conceived the project long before; but the then recent siege of Vienna by the Turks had caused him 'to take up again with his plan for discoursing at a distance, not by sound, but by sight.' The principle involved the use of telescopes, but it was less simple and ingenious than that which afterwards came into use.

Guillaume Amontons, a Frenchman, appears to have been the first to render a telegraph available for practical purposes about 1690, by 'a means which,' as recorded by Fontenelle, 'he invented to make known all that was wished to a very great distance—for example, from Paris to Rome—in a very short time, three or four hours, and even without the news becoming known in all the intervening space. This proposition, so paradoxical and chimerical in appearance, was executed over a small extent of country, once in presence of Monseigneur, and afterwards before Madame. The secret consisted in placing in several consecutive stations persons who, by means of telescopes, having perceived certain signals at the preceding station, transmitted them to the next, and so on in succession, and these different signals were so many letters of our alphabet, of which the key was known only at Paris and Rome. The greatest reach of the telescopes determined the distance of the stations, of which the number was to be the fewest possible; and as the second station made signals to the third as fast as they were seen at the first, the news was carried from Paris to Rome in almost as little time as it took to form the signals at Paris.' For this public exhibition of his apparatus, Amontons was indebted to the intrigues of Mademoiselle Chouin, a princely favourite; but the dauphin was too indolent to make an effort towards encouraging the invention, and it shared the fate of many others—neglect.

Another projector, named Marcel, followed with no better fortune than his predecessor. Wearied with attendance on a dilatory government, he broke his machine and burnt his drawings, and died without revealing his secret. Next, Linguet, who had been for some years a prisoner in the Bastille, claimed the merit of the invention, and offered to construct a telegraph in exchange for his liberty. History is silent as to his offer being accepted. In course of time a private attempt was made: Monsieur Dupuis of Belleville constructed a telegraph, by means of which he communicated with his friend Fortin, who lived a few leagues off at Bayeux. Meantime Mr Edgeworth had published his plans in Ireland; Bergstrasser of Hanau had investigated every branch of telegraphy: flame, smoke, reflection, rockets, detonations, torches, bells, trumpets, flags, and mirrors; and attention being drawn to the subject in other quarters, shewed that the time for realising a speedy-transmission project was at hand.

It came at last with its man. Claude Chappe, when a youth in a religious establishment at Angers, had contrived an apparatus, a post, bearing a revolving beam, and circulatory arms, with which he conveyed signals to three of his brothers who were at a school about half a league distant, and read them off with a telescope. Keeping the idea in view for several years, he eventually laid his plans before the legislature in 1792, assuring them that 'the speed of the correspondence would be such, that the legislative body would be able to send their orders to the frontiers, and receive an answer back, during the continuance of a single sitting.' After much vexatious delay, the sum of 6000 francs was granted to enable him to make an experiment near Paris; but his first apparatus was stolen by a party of men in masks, and no sooner was it reconstructed, than the populace burnt the work to the ground, stupidly imagining that certain direful machinations were involved in the signals. A third trial was more successful; the authorities approved the plan, and Chappe, with the title of Ingénieur Télégraphe, was appointed to erect a telegraph from Paris to Lille. The French armies were on foot, and speedy intelligence of their successes or reverses was most desirable.

The line, with its apparatus, which admitted the formation of 192 different signals, was completed in two years. Its first announcement was a victory. On the last day of November 1794, Carnot entered the Assembly with the news, 'Condé is given up to the Republic! The surrender took place this morning at six.' The Chamber voted that 'the Army of the North had deserved well of the country,' and caused their approval to be sent to head-quarters; and before the legislators broke up, they were informed that their orders had been transmitted to Lille, and the receipt acknowledged. Such an incident in the infancy of the new art was hailed with enthusiastic acclamations.

This successful result led to the immediate formation of the other lines which radiated from Paris to all the frontiers of the kingdom. The signals were conveyed with great rapidity; and to avoid confusion, the movable arms on the right of the central post were kept exclusively for government messages, those on the left being employed in the service of the line. Thus accidents or delays could be reported without detriment to the official despatch. From Paris to Calais, 152 miles, there were thirty-three stations, and a message could be sent from one extremity to the other in three minutes; to Strasburg, 255 miles, and forty-four stations, in six and a half minutes; to Toulon, 317 miles, and one hundred stations, in twenty minutes. The longest lines were to Brest and Bayonne; the former 325 miles, the latter 425; and altogether there were 519 stations, the annual cost of which amounted to £40,000. It has happened, sometimes, when one part of the country was obscured by fogs, that information has been conveyed to the capital by the longer route; on one occasion news from Lyons travelled to Paris by way of Bordeaux. The last of the brothers Chappe was in office until 1830, when the July revolution deprived him of his post and its emoluments.

The new mode of correspondence was speedily adopted by the other governments of Europe, and numerous forms of apparatus were proposed by enterprising inventors, some of them remarkable for the infinite multiplicity of their signals.. The first line of telegraph established in England, in 1796, extended from London to Dover, speedy transmission of Channel news being then of prime importance. Portsmouth and the Admiralty were afterwards brought into communication by a system of signals not before adopted—a vertical post with two movable arms, that could be placed in forty-eight different positions. The maintenance of this line, seventy-two miles, involved a charge of more than £3000 yearly. It was given up in 1847.

With all its advantages, however, the aërial telegraph, as it was called, was a necessarily imperfect contrivance, being altogether useless at night, and during fogs or gloomy and rainy weather. For three-fourths of the year the Admiralty telegraph stood idle: 1600 hours in the twelvemonth were reckoned as its available capability. A foul-weather telegraph was conceived to be an impossibility, and the system of night-signals by means of lamps and reflectors was far from perfect, notwithstanding the endeavours after improvement. One of the most satisfactory, by the Rev. J. Bremner of Shetland, gained the gold medal of the Society of Arts in 1816. Couriers, mail-coaches, and dispatch-boats, were still the grand resource.

We turn now to another part of the general subject under consideration, not less interesting than important—that of electricity. Its history carries us back to the age of conjecture and the dawn of philosophy. Six hundred years before the birth of Christ, Thales had observed that amber, or *elektron*, as the Greeks called it, exhibited, when rubbed, certain properties of attraction which it did not otherwise possess. Besides giving us the word in which our term *electricity* originates, the early philosophers left behind them several accounts of electrical phenomena. Aristotle, Theophrastus, Pliny, Cæsar, and Plutarch, all mention them. Singular flames were sometimes seen on the tops of the masts of ships in the Mediterranean, or quivering on the heads of the wondering mariners; and on several occasions Roman troops, while on a march, had observed similar luminous appearances on the points of their lances. And coming down to a later period, we find Eustathius, in his commentaries on Homer, relating the case of Walimer, father of Theodoric the Goth, whose body gave out sparks; and of another individual who, on drawing off his clothes, saw flames or scintillations leap from his skin with a crackling noise. From Thales to the twelfth century is a long period, yet scanty as is the record of facts, it is sufficient to shew that electrical phenomena had not passed without notice; but, as far as we know, no attempt was made to reason upon them, or define their nature. The first approach towards such a result was the treatise 'De Magnete,' published by Gilbert, an Englishman, at the end of the sixteenth century. He classifies all the then known electric substances, and enters into some discussion on the electricity of the air and the earth. The latter subject, in particular, engaged the attention of philosophers whose names are yet famous—Father Kircher, Descartes, Halley, and others. According to some theorists, iron crept about or grew within the body of the earth, and its transmission along deeply-buried tubes, provided by nature, was the cause of magnetic variation at the surface. Within the next fifty years the Prussian, Otto Guericke, produced the first electrical machine—a globe of sulphur made to rotate by means of a winch, while the friction of a piece of cloth held against it excited the electrical influence. He discovered one or two of the principles of the science, particularly that of the electric fluid passing from one body to another without actual contact, but missed the deduction of consequences from a fact since recognised as essential.

The eighteenth century came, and opened the most famous page in the history of electricity. For Guericke's ball of sulphur, Hauksbee substituted a globe of glass, while other experimentalists used straight glass tubes rubbed with the hand. Stephen Gray found that all substances might be classified as electrics and non-electrics; and, by means of packthreads more than a hundred feet in length, was the first to prove that the electric impulse could be transmitted to a considerable distance. In company with his friend Wheeler, he discovered also the insulating properties of glass, silk, hair, and resin, besides some other bodies. In France, Dufaye and Nollet were labouring diligently at the same pursuit. By wetting a cord, they observed that Gray's experiment could be greatly extended. They sent a current through thirteen hundred feet; and following up the reasoning of their English contemporary, 'Dufaye suspended his own person by silk lines, and being electrified, the Abbé Nollet, who assisted him in these experiments, presented his hand to his body, when immediately a spark of fire issued from the person of the one philosopher and entered the body of the other. Although such a result had been predicted as a consequence of the arrangement, the astonishment was not the less great at its occurrence. Nollet states, that he can never forget the surprise of both Dufaye and himself when they witnessed the first explosion from the body of the former.'

To Dufaye belongs the merit of discovering the two kinds of electricity, which he named *vitreous* and *resinous*, or, according to the present terminology, *positive* and *negative*. To call them two different manifestations of one and the same grand natural agency, would perhaps be a better interpretation of the phenomena. Germany next added a few facts to the growing science. A Scottish monk at Erfurt, by adopting glass cylinders, gave to the electrical machine almost its present form, and marvellous effects were produced. In 1746, the three philosophers of Leyden produced the jar which still in name perpetuates the place of its discovery. The power of the shock, probably owing to its novelty, appears at that time to have been greatly exaggerated. Muschenbroek, writing an account of the experiments to Réaumur, states that 'he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and the terror;' and adds, that 'he would not take a second shock for the whole kingdom of France.'

But leaving particulars, the investigations which most claim our attention are those which relate to the transmission of electricity to long distances. With lengths of wire held by human hands, Nollet formed a chain more than 5000 feet long, and found that the passage of the shock through the whole number of individuals was instantaneous. The same fact was still more satisfactorily demonstrated in England by Dr Watson, an eminent Fellow of the Royal Society. He carried a wire across the Thames at Westminster Bridge, one end being in contact with a charged jar, the other held by a person on the opposite shore. A second individual was placed in communication with the jar, and on a given signal the two dipped into the river an iron rod which they held in their hands, on which the shock travelled from one side of the stream to the other by means of the wire, and came back through the water to complete the circuit. This was an important discovery, inasmuch as it involved the principle on which depended all subsequent experiments on transmission to a distance. Watson repeated his experiments on several occasions, the last time near Shooter's Hill, with two miles of wire; and the now familiar fact that observers, however far apart, feel the shock at the same instant, then excited a degree of astonishment bordering on incredulity. Franklin's famous kite-experiment, which proved the identity of lightning and electricity, may be regarded as the climax of electrical discovery in the past century. No sooner had the general nature of the new and startling phenomena become known, than the idea immediately sprang up of employing the mysterious agency in the conveyance of signals. Maunoir relates, that in 1773 Odier wrote to a lady of his acquaintance—'I shall amuse you, perhaps, in telling you that I have in my head certain experiments by which to enter into conversation with the emperor of Mogol or of China, the English, the French, or any other people of Europe, in a way that without inconveniencing yourself, you may intercommunicate all that you wish, at a distance of four or five thousand leagues in less than half an hour! Will that suffice you for glory? There is nothing more real. Whatever be the course of those experiments, they must necessarily lead to some grand discovery; but I have not the courage to undertake them this winter. What gave me the idea was a word which I heard spoken casually the other day at Sir John Pringle's table, where I had the pleasure of dining with Franklin, Priestley, and other great geniuses.'

A short time previously, according to Maunoir, who adds that Odier was then devoting much attention to electricity, the latter wrote to the same lady—'Is it not astonishing that the movement of a morsel of straw, attracted by a piece of amber, should have suggested to Franklin the sublime idea of the lightning-conductor? Franklin was the first to discover the secret of imprisoning the electric fluid in a bottle.'

Other minds were also occupied with the subject: in 1774 Lesage, a Frenchman at Geneva, published a plan for an electric telegraph, which he submitted to Frederick of Prussia, conceiving that monarch best capable of realising it. He proposed to arrange twenty-four metal wires in some insulating substance, each connected with an electrometer, from which a pith ball was suspended. On exciting the wires by means of an electrifying machine, the movements of the twenty-four balls represented the letters of the alphabet, as might have been agreed on. The project, though ingenious, was never carried into execution, and would have failed at great distances, owing to an essential defect to be presently noticed.

Arthur Young, in his 'Travels in France,' gives us an account of a somewhat similar contrivance, which affords further evidence of the interest felt in the subject of electric communications. Under the date September 16, 1787, he writes:—'In the evening to Monsieur Lomond, a very ingenious and inventive mechanic. In electricity he has made a remarkable discovery: you write two or three words on a paper; he takes it with him into a room, and turns a machine enclosed in a cylindrical case, at the top of which is an electrometer, a small fine pith ball; a wire connects with a similar cylinder and electrometer in a distant apartment; and his wife, by remarking the corresponding motions of the ball, writes down the words they indicate, from which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance: within and without a besieged town, for instance; or for a purpose much more worthy, and a thousand times more harmless—between two lovers prohibited or prevented from any better connection. Whatever the use may be, the invention is beautiful.'

A method proposed by Reiser in Germany, in 1794, exhibited illuminated signals. Plates of glass partially covered with tinfoil were connected by wires with a machine, and sparks of light became visible on the uncovered parts of the glass when the electric current was passing. Cavallo, again, in his treatise on electricity, published in 1795, suggests the explosion of a Leyden jar as a means of arousing the attention of the distant operator. In the following year Salva, a Spanish physician, who in defiance of the opposition of bigoted monks and popular ignorance, had earnestly promoted the cause of vaccination—constructed an electric telegraph, and described it in a memoir which he laid before the Academy of Sciences of Madrid. The Infant Don Antonio was so much interested in the invention, that he caused a telegraph to be erected, and turned it to practical use. Shortly afterwards a more extensive attempt was made by Betancourt, who stretched wires from Aranjuez to Madrid, a distance of forty-five miles, and conveyed his signals in the discharge of jars. One after another, however, the schemes failed in subordinating the element of electricity to their purposes; the human mind had to be tasked to yet greater efforts, and the period of their realisation was not far distant. Of all the projects for establishing a telegraph with frictional electricity as its active principle, the most complete was that published by Mr Francis Ronalds in 1823.

There is something eminently gratifying in the consideration of science pursuing its even course undisturbed by political convulsions. While England was losing her right to the American colonies in the wanton exercise of might, and while the social elements were fermenting on the continent, to break out in the agonies and horrors of the French Revolution, philosophers were quietly penetrating the secrets of nature, and searching for fuller and clearer knowledge. They had their reward.

The telegraphs here brought under notice failed, because they were worked by statical electricity—that is, electricity obtained by friction, or from Leyden jars. This kind of electricity is remarkable for what is called its *tension*, or tendency to fly off from its conductors. It is an agent not to be depended on or held in control, and proves itself often capricious, from various causes, some of them inappreciable: among the known, damp is one of the most influential. Hence the realisation of electric telegraphs on a large scale was essentially impracticable. Signals, it is true, might have been transmitted within a building, but not for miles out of doors, in all weathers. For the further development of telegraphy, we are indebted to dynamic electricity, or electricity without tension; that is, without a tendency to abandon the conductors along which it travels. Its phenomena, when compared with those of statical electricity, are much more striking and interesting.

In the whole history of accidental discovery, there is no event more remarkable than that by which that other form of electricity, known as galvanism, was brought to light. To quote M. Arago: 'It may be proved that this immortal discovery arose in the most immediate and direct manner from a slight cold with which a Bolognese lady was attacked in 1790, for which her physician prescribed the use of frog broth.'

In accordance with the medical advice, a number of frogs were prepared for stewing, and by some chance a few of them were laid on a table near an electrical machine, in the laboratory of Galvani, professor of anatomy at Bologna, and husband of the lady in question. An assistant working in the apartment had occasion to draw sparks from the machine, and each time that he did so, Signora Galvani observed that the limbs of the dead frogs moved as though alive. She called the professor's attention to the fact; he repeated the experiment, and with the same result. But without intending it, he went farther than this, and found that the limbs of frogs could be excited as well by means of good conductors as by a machine. The power was present, and required only an efficient cause to develop its action. Galvani, it is said, having prepared the hinder halves of several frogs for anatomical investigation, 'passed copper hooks through part of the dorsal column which remained above the junction of the thighs, for the convenience of hanging them up till they might be required for the purposes of experiment. In this manner he happened to suspend several upon the iron balcony in front of his laboratory, when, to his inexpressible astonishment, the limbs were thrown into strong convulsions.' On examining further into the phenomenon, he ascertained that it could be produced at pleasure by touching the surface of a nerve and of a muscle at the same time with a metallic conductor; and arguing from the whole body of facts that came within his experience, he propounded a theory of animal electricity which for some time dazzled the imaginations and stimulated the enthusiasm of a host of partisans, according to whom the existence of a 'nervous fluid' had been demonstrated by the experiments.

A new explanation was soon to appear. Volta, professor of natural philosophy at Pavia, reasoning upon Sulzer's experiment, in which the placing of a piece of lead and another of zinc, above and below the tongue, produced a peculiar effect on bringing the edges of the two pieces of metal into contact, and on the fact that a similar taste is perceived on applying the tongue to a charged electrical conductor, came to the conclusion that electricity was the cause of the phenomena witnessed by Galvani, and considered by that philosopher as due to some property inherent in the nerve or muscle. Volta had observed also that the excitement of the organism was greater when touched with two different metals than when only one was used, and from this result deduced the fact that the electricity resided in the metals, not in the nerves, and that bringing them together was the cause of the phenomenon. By pursuing the inquiry, further conclusions were arrived at; and Fabroni, another Italian, in a memoir which he communicated to the Florentine Academy, ascribed the electrical effects to chemical action.

After continued application, Volta at length discovered the instrument now known as the Voltaic pile. At first it was a circle of small cups partially filled with salt water, and containing plates of zinc and silver connected by wires. It was subsequently modified into its present form—a pile of alternate disks of zinc and copper kept separate by the interposition of disks of pasteboard moistened in an acid solution. He announced this discovery in a letter to Sir Joseph Banks, president of the Royal Society, in March 1800, and won for himself a reputation in the foremost ranks of science. He had found the means of accumulating and rendering continuous the power which had baffled Galvani.

At Napoleon's invitation, Volta visited Paris in 1801, and explained and illustrated his theory of contact of metals and electro-motive action to the members of the Academy of Sciences. The First Consul was one of the audience; and 'when the report of the committee on the subject was read, he proposed that the rules of the Academy, which produced some delay in conferring its honours, should be suspended, and the gold medal immediately awarded to Volta, as a testimony of the gratitude of the philosophers of France for his discovery. This proposition being carried by acclamation, the hero of a hundred fields, who never did things by halves, and who was filled with a prophetic enthusiasm as to the powers of the pile, ordered two thousand crowns to be sent to Volta the same day from the public treasury, to defray the expenses of his journey.'

The terms galvanism, or voltaic electricity, were applied to the newly-developed principle in honour of the two discoverers. Familiarity with their effects has scarcely divested them of their wonder-compelling character. The tongue-experiment is a household sport with many persons; and numbers besides know that an action is produced by leaning a strip of zinc against a strip of copper in a tumbler of muriatic acid. This action is, however, the most subtle, and as yet the most extraordinary of nature's manifold agencies. With two sorts of metal and an acid the current immediately begins to flow. In some of its effects it resembles electricity, yet there are essential differences. Galvanism must have a continuous conductor; electricity will leap over short distances from one to another. The one is steady, the other uncertain. Iron can be magnetised by galvanism, not by electricity. Thus we appear to have two forces, alike yet unlike; both mysterious, and peculiarly inciting to philosophical investigation.

The announcement of Volta's discovery drew the attention of many inquiring minds to the subject all over Europe. In chemical researches more particularly the powers of the pile were made largely available. Ritter of Munich, in 1805, found that pieces of metal could be magnetised by the voltaic current; and in 1807 the famous Danish physicist, Oersted—whose recent decease is a great loss to science—made certain observations on the same phenomenon, which he diligently pursued and reconsidered, until he arrived at his celebrated discovery in 1819. It consisted in the capital fact that the needle of a compass, when placed above or below a voltaic wire stretched from north to south, and forming a complete circuit, deviated from its normal position, and shewed a tendency to place itself at right angles with the current. There was, besides, the remarkable phenomenon, that when the needle was *below* the wire, its south pole diverged to the west, if the current were passing from south to north, and to the east when flowing in the reverse direction: with the needle *above* the wire, directly opposite effects were produced. This was a discovery scarcely less important than that of the voltaic current, being, at the same time, the result of patient and long-continued inductive research, and the immediate cause of further application. Oersted first made it public in 1820, in a Latin memoir, in which he demonstrates the laws of the phenomenon, and states that by the meeting of two electric currents, a new development of power takes place, which attracts or repels the north pole of the needle, according as it is positive or negative; that the direction of this power is not in a right line, but a spiral—a view remarkable for its sagacity, and which subsequent experience has affirmed.

Oersted's discovery excited an admiration and activity among the learned not inferior to that which had greeted Volta and his pile. Among the foremost to elucidate the subject and extend the inquiry, Ampère stands prominent. In less than three months after the publication of the Danish philosopher's researches, he laid a paper on electro-magnetism before the Academy of Sciences at Paris, demonstrating the dynamical laws of the science from experiment and mathematical calculation. He considers that the battery calls into play two currents in the wire, moving in opposite directions, and thereby producing magnetic action; and shews that similar currents circulate about the poles of a magnet. The two currents exert a dynamic action on each other, varying according to direction. 'Two straight wires, along which currents are transmitted, will attract or repel each other, according to the direction of the currents. Let a line be imagined intersecting both wires at right angles. If both currents move towards this perpendicular, or both from it, the wires will attract each other; but if, while one of the currents moves towards this perpendicular, the other moves from it, then they will repel each other.' In proof of his statements, Ampère produced various contrivances, made chiefly of wire, to illustrate the phenomena; among them were small helices, which behaved as magnets while a current was passing through them. In the same year, too, Arago found that on plunging the wires of a battery into steel filings, the latter attached themselves to the wires, and remained adherent as long as the circuit was complete, but fell off on the instant of breaking contact. Here was another important step in advance: a wire could be magnetised at pleasure. It led to the discovery by Mr Sturgeon, a few years later, of magnets of almost inconceivable power, by placing a bar of soft iron within a helix of copper wire, connected with a battery. As in the case of the steel filings, it became a magnet, or ceased to be such, every time that contact was made or broken. The straight bar was afterwards bent in the form of a horse-shoe, and its attractive power so much increased in consequence, that in some instances from two thousand to three thousand pounds have been sustained. The new power partook somewhat of the tremendous, and every fact that threw light upon it served but to stimulate the ardour of inquiry. Faraday's researches have rendered signal service to the progress of electro-magnetism, particularly his discovery of induction, which he describes as 'the effect of the actions of contiguous particles.' He tested it by an extensive series of experiments on various solid and aëriform substances, under different pressure and temperature. The late Professor Daniell states, as an explanation of the theory, that 'as every electric current is accompanied by a corresponding intensity of magnetic action at right angles to the current, good conductors of electricity, when placed within the sphere of this action, should have a current induced through them, or some sensible effect produced, equivalent in force to such a current.'

To enumerate the names only of those who have advanced the science of electro-magnetism, apart from any mention of their labours, would fill a long list. At the period more immediately under notice, Schweigger, De la Rive, Moll, Cumming, Barlow, and Christie, were multiplying facts, or deducing laws from those already known. Besides these, Ohm of Nuremberg rendered distinguished service, by establishing the mathematical laws of electric currents, and demonstrating the values really attaching to the terms 'quantity' and 'intensity;' at the same time giving formulæ on which the various actions and effects might be calculated. Electricians, wherever employed, have been highly indebted to his labours, which have so greatly facilitated the application of the science.

Prior to Oersted's discovery of the deflection of the needle, several attempts had been made to apply voltaic electricity to telegraphic purposes. The first was by Soemmerring of Munich in 1811. But here we may pause a moment to consider the singular account recorded in the 'Spectator.' The author referred to by Addison is the Jesuit Famiano Strada, who was master of rhetoric at Rome, and published his 'Prolusiones Academicæ' in 1617. This work contains the account in question, the purport being, that correspondence might be carried on between two individuals widely separated by means of a certain magnetic agency. According to Strada, it was not a new idea; he ascribes it to Cardinal Bembo, who died at Rome in 1547, and explains that it came to him by hearsay from several eminent persons, through whom it could be traced back to its reputed originator. Without attaching undue importance to this statement, it seems nevertheless to carry us back to a date earlier than any yet recorded for the inception of a project for rapid communication to long distances.

Strada's version, as a recent translation shews, differs from the summary given in the 'Spectator.' He says in commencing: 'Magneti genus est lapidis mirabile;' and after describing the properties of the loadstone, proceeds: 'Now, then, if you wish your distant friend, to whom no letter can come, to know anything, take a disk (or dial), then write round the edge of it the letters of the alphabet, in the order in which children learn them, and in the centre place horizontally a rod which has touched the magnet, movable, so that it can touch whatever letter you wish.' A similar instrument is to be made, which 'disk let the friend about to depart take with him, and agree beforehand at what time, and on what days he will examine whether the rod trembles, and what letter it points to with its index. These matters being thus arranged, if you desire privately to speak to the friend whom some shore of the earth holds far from you, lay your hand on the globe, turn the movable iron—there you see disposed along the margin all the letters which are required for words; hither turn the indicator, and the letters, now this one, now that one, touch with the style; and while you are turning the iron through them again and again, you separately compose all the ideas in your mind. Wonderful to relate, the far-distant friend sees the voluble iron tremble without the touch of any person, and run now hither, now thither; conscious he bends over it, and marks the teaching of the rod, and follows, reading here and there the letters which are put together into words: he perceives what is needed, and learns it by the teaching of the iron. And moreover, when he sees the rod stand still, he, in his turn, if he thinks there is anything to be answered, in like manner, by touching the various letters, writes it back to his friend.' Here Strada becomes impressed with the importance of his subject, for he breaks out—'Oh may this mode of writing prove useful! Safer and quicker thus would a letter speed, nor have to encounter the snares of robbers or impediments of retarding rivers. A prince might do the whole business (correspondence) for himself with his own hands. We children of scribes, emerging from the inky flood, would then hang up our pens in votive offering on the shores of the magnet.'

Without stopping to inquire whether in this Strada wished to perpetuate the history of a lost art, or was merely giving play to his imagination, we return to Soemmerring, who, in the year mentioned, proposed a scheme for a voltaic telegraph to the Academy of Sciences at Munich. It comprehended as many wires as the letters of the German alphabet, and the numerals 0 to 9, which terminated in thirty-five gold points in a vessel of water. When the current passed from the pile, decomposition of the fluid took place, and a bubble of oxygen or hydrogen appeared at the point or letter to which attention was desired. Soemmerring appears to have been aware that the motion of electricity was swifter than that of light; and in his memoir he sets forth the advantages to be derived from such a form of telegraph—its availability by night or by day, in fog or in cloud, and its invisibility while *en route.* The contrivance, although ingenious, failed in one particular: there was nothing to arouse the attention of the correspondent. A means for this purpose was subsequently added by Schweigger, who shewed also that two wires would be more effectual than the greater number, and that it would not be impossible to print the communications from one end of the wire to the other—thus anticipating two of the most remarkable peculiarities belonging to the present form of electric telegraph.

The deflection of the needle—that proof of 'magnetic action at right angles to the current'—appears to have been most studied as a medium for signals, and became the subject of eager experiment. The current, however, when passed along any considerable length of wire, was found insufficient to produce a well-defined movement. This defect was remedied by Schweigger, in an instrument which he invented, and called the *multiplier*—a name expressive of its essential principle. It is astonishingly sensitive, and has proved most valuable in the study of electro-dynamics. The construction is based on the fact, that a current returning upon itself, acts in all its parts, and causes a powerful deviation in a magnetic needle placed within it. As described by Moigno: 'A conducting wire twisted upon itself, and forming a hundred turns, will, when traversed by the same current, produce an effect a hundred times greater than a wire with a single turn; provided always that the electric fluid pass through the circumvolutions of the wire without passing laterally from one contour to another. This is a condition easy to fulfil. To make a multiplier, you take a silver or copper wire of any length or size, closely enveloped in silk thread, and wind it round a small frame, within which the needle is suspended on a pivot, and leaving a few inches free at each extremity. These are called the two wires of the multiplier, and when in work, the current enters by one end and passes off at the other.' With this contrivance, of which more remains to be said, a great difficulty was overcome.

The discovery of thermo-electricity by Seebeck of Berlin is so far related to our subject as to claim a brief notice. He found that by applying heat to one extremity, or to any part of pieces of metal, they could be made to give out electric currents. One end of a short bar being raised in temperature, a circulation of a current is produced through the whole mass. Here is a phenomenon singularly illustrative of the magnetism of the earth, and corroborated by Faraday's recent discoveries. 'The sun,' it is said, 'would thus become the exciting agent, whose uniform tide of heat, sweeping the tropical zone, would be productive of an immense westerly circumflowing electric flood, and thus convert the terrestrial ball into a grand thermo-electric magnet.'

The new science was gradually assuming a definite combination: two French *savans*, in the course of their investigations, found that a long extent of the iron of a railway could be used to complete a circuit, and bring back the reverse current. Becquerel had shewn, too, in carrying out Volta's researches, that a pile might be constructed with a constant though feeble current; and the finding of a stronger power became of importance. The pile was replaced by batteries of various form, among which the constant battery constructed by Professor Daniell supplied the long-sought desideratum. The zinc was plunged into a solution of chloride of sodium, and the copper into a solution of sulphate of copper. The products of decomposition were disposed of by an ingenious contrivance, and loss of power provided against, so that the action maintained its full force for a considerable period. Batteries still more powerful have since been invented: the liquids employed have been varied, and charcoal and platinum substituted for copper. One by Wheatstone required but a single liquid, sulphate of copper, in which was plunged a porous vase filled with a pasty amalgam of zinc, producing a constant action. Thus by degrees the elements of telegraphing were prepared: there needed but the mind to combine them.

This distinction is claimed by Professor Morse, an American, having, as he says, invented the first electro-magnetic telegraph while on his passage from Havre to New York in 1832. His contrivance included a pen at one end of a wire, which, as contact was made or broken, produced an arbitrary alphabet of dots and strokes, which might represent definite characters. An experiment with a circuit of ten miles was tried before several scientific men well known in the United States, and members of Congress; and the result being favourable, a sum of money was voted by the government for a trial on a larger scale. The account of these proceedings appears not to have been published earlier than 1837; meantime Baron Schilling of St Petersburg had constructed an electric telegraph, but died before its complete development. By his method, movements were imparted to five needles, out of which a code of signals was formed. Gauss and Weber's experiments and deductions, published in 1834, brought the possibility of electro-telegraphy still more within reach. To these two philosophers the theory of the science is materially indebted. The first-mentioned, the venerable professor of Göttingen, has been called its father, such are the sagacity and insight which he has brought to bear on so intricate a subject.

We come now to 1837, the year in which the projects of electro-telegraphy became available realities. Steinheil of Munich succeeded in sending a current from one end to the other of a wire 36,000 feet in length, the action of which caused two needles to vibrate from side to side, and strike a bell at each movement. The bells were made to differ in tone, so as to indicate distinctly right and left signals; at the same time, to combine a phonic and a written alphabet, certain points tipped with ink impressed dots upon a band of paper, and recorded the desired message. In the course of his researches Steinheil proved a fact, the most interesting perhaps in telegraphic science—that instead of using two wires, the earth would serve to complete the circuit. This verification of a phenomenon so extraordinary in its nature—one which is still to be explained—has been attended with the most important results in the economy of telegraphs, and will tend more to keep Steinheil's name in memory than his mechanical apparatus, which was said to be too complicated and tedious in operation for any one but a German.

It was in 1837 also, that Wheatstone, whose name is so intimately associated with telegraphic progress in England, took out his first patent for an electric telegraph. He had been led to the invention by his experiments to determine the velocity of electricity in 1834, and proposed a system of five conducting wires in connection with as many needles, which indicated the letters of the alphabet at the rate of twenty a minute. Attention was to be drawn to the signals by the stroke of a bell, forming part of the apparatus.

It would be supposed that when the eye and the ear had been addressed, telegraphic communication had achieved all that was required of it; but Mr Vorsselman de Heer of Deventer invented an apparatus which imparted its signals through the sense of touch, and was based on the principle that to produce an effect by this medium demands a much smaller power of electricity than to deflect a needle. He employed ten wires, and obtained forty-five different combinations, which were felt by placing the finger-tops on the keys of the instrument, and attracted the notice of the attendant by a wire attached to his person night and day: even if in bed he was to be aroused by the shock. The cost would have been about one-eighth of the usual expense of telegraphic apparatus at that period. Much ingenuity was displayed in the whole arrangement, which, under certain conditions, would be more useful and available than any other.

In 1840 Wheatstone had made improvements which greatly simplified his first methods; the number of wires was reduced to two, while the power of the instrument was increased, for thirty letters could be indicated in a minute. Besides this, the same inventor shewed that the passage of a current afforded means for other spheres of observation. Travelling at a speed that would circumvolate the globe seven or eight times in a second, it might measure the rate of motion of projectiles, or regulate the movement of all the clocks in a country; and by an additional contrivance the place of fracture in a wire could be ascertained without the necessity of examining its whole length. A telegraphic wire was to bring down from a balloon, stationary at a considerable height, the readings of a set of philosophical instruments; to record the state of fluctuations of a barometer, thermometer, hygrometer, and magnetometer. The apparatus for a series of experiments of this nature was actually prepared, and is still kept in readiness for a fitting opportunity. This principle has since been reduced to practice by Mr Smee:—

'Behind my house,' he observes, 'is a small hothouse; and I conceived the idea of constructing a simple telegraph which should inform me of the temperature. Now my plants would be injured if the heat fell below 50° or rose above 90°, and I therefore wished to have some contrivance which should inform me in my own study whether the temperature were remaining or not within these limits. For this purpose a thermometer was made for me, into which two platinum wires were inserted, which came in contact respectively with the mercury at those two points. By this contrivance, when the heat either fell below or rose above those two points, the mercury and platinum were not in contact, and a voltaic current could not be maintained. Telegraphic communications were laid down from these two platinum wires to my dwelling-house; and a large pair of zinc and copper plates were sunk into the ground for a battery. By attaching the wires to a galvanometer we can always ask how the temperature is; and by attaching an alarum, a gardener might be warned of any accident at any time of the night.' Then in the same way that the catch of the telegraph alarum is liberated, so might the stop of ponderous machinery be released, regardless of distance, and effects of commensurate importance be produced. With a proper combination of machinery, a lady, seated in her drawing-room in London, might play Beethoven's symphonies on the piano of her friend at Edinburgh; or a ringer in St Paul's belfry might entertain the frequenters of the Parliament Square with a lively carillon from the tower of old St Giles's. Still more remarkable is the application of electro-magnetism as a motive agent. If, as appears from experiments recently made in America, it can be made to move a ton weight of iron, it is not easy to define the limits of its power.

The employment of the printing apparatus in 1843 gave to the electric telegraph a wider and completer efficiency. This contrivance, when attached to the telegraph machinery, and set in motion by wheelwork, caused a ribbon of chemically-prepared paper to pass under a fine steel point, which imprinted a series of arbitrary characters—dots and strokes—simultaneously with their transmission from the other end of the telegraph, however distant. Although seventy or eighty characters could be produced in a minute, the whole process was tedious, as the message had first to be punched in a strip of paper, and then written off after its delivery. In America the preliminary punching was avoided by making the operator open or close the galvanic circuit for longer or shorter intervals, by pressing on the spring-key of the telegraph: according to the duration, strokes or dots were produced. Since that time improvements have been made which print the message in the Roman character, and accelerate the rate of transmission. The latter, there is reason to hope, will shortly become still more rapid, should Mr Wheatstone succeed in his endeavour to communicate 180 distinct signals in a minute. Already Bakewell's copying telegraph is a great advance upon that of the arbitrary signs. 'When this means of correspondence is in operation,' as is stated, 'instead of dropping a letter in the post-office box, and waiting days for an answer, we may apply directly to the copying telegraph, have it copied at the distant town in a minute or less, and receive a reply in our correspondent's handwriting almost as soon as the ink is dry with which it was penned. There are various means, too, for preserving the secrecy of correspondence; the most curious of which is, that the writing may be rendered nearly invisible in all parts but the direction, until its delivery to the person for whom it was designed.'

The success that has attended the progress of electro-telegraphy has, as is usual in such cases, called up a host of claimants to the various inventions or discoveries. More than sixty have been enumerated. We are, however, too apt to overlook the fact, that discovery is rather the consequence of tendencies of thought and progress on the part of numbers, than of sudden individual conception. The elaboration of a great moral or scientific truth, and its application to the wellbeing and advancement of society, are results not less honourable to those who have assisted in producing them than to the prime originator—if such there be: remembering always that but for the thought and travail of previous generations, our own achievements would be slender indeed.

The first application of the electric telegraph was made on the Blackwall Railway, from the station in the Minories to Brunswick Pier. On this line the trains start every quarter of an hour, and the stopping places are so numerous, that it is not easy to conceive how the service could have been performed without such aid as the new mode of telegraphing was calculated to afford. The announcements of departures, of stoppages, of the number of carriages attached to the wire rope, accidents, or other causes of delay, were regularly transmitted, and the business thereby maintained in full vigour and discipline. After this, other railway companies availed themselves of the same indispensable agency, and telegraphs were gradually stretched along the London and North-Western, South-Western, South-Eastern, and Eastern Counties lines. On the Great Western the wires at first were placed inside a continuous tube, fixed a few inches above the ground at one side of the way, but were afterwards strained on posts, as on other railways—an arrangement, with slight exceptions, now prevalent throughout Britain. This line had not long been complete when a striking instance occurred of the service which the telegraph might render to society. A man of respectable exterior took his seat in a first-class carriage at the Slough station, eighteen miles from London: he was a murderer hurrying away from the yet warm body of his victim; the panting engine nears its destination; the eager criminal believes his escape certain; but the alarm has been given at the fatal spot, and quick as lightning the telegraph transmits it to Paddington, with a description of the suspected individual. In three minutes an answer announces the arrival of the train, the identification of the fugitive, and the certainty of his capture. There are few persons who will not remember the impression made on the public mind by this victory of science and justice over crime. Again: a communication transmitted from Paddington immediately that the year 1845 commenced, was received at Slough in 1844, the clock at that place not having struck midnight. Though so short a distance, the difference of longitude was sufficient to mark the inconceivable velocity of the electro-magnetic current. Swift-footed Time was henceforward to be beaten in the race. A still more remarkable instance of the same nature occurred in America: a message flashed from Washington when the New Year was a quarter-hour old, was read off at New Orleans with half an hour of the old year yet to run.

The wire commonly used for telegraphs is about one-sixth of an inch diameter, covered with a thin coating of zinc, or, as it is called, 'galvanised,' to prevent oxidation. Besides this, it is found that the deposit from damp and dust and other causes affords a very efficient protection. Four miles of such wire weigh a ton. The posts to which it is attached are fixed at from fifty to sixty yards apart—thirty or thirty-two to the mile. To insure perfect insulation the wires are not permitted to touch the posts, otherwise the current would be diverted downwards through the wood, particularly in wet weather. Insulators of various forms, 'rings, collars, and double cones,' are made of brown stoneware, which of all substances yet tried throws off the wet most readily. A stone-pitcher, after being plunged into water, is seen to retain scarcely a trace of the immersion beyond a few drops on the surface. Even with this material it is sometimes difficult, during dense fogs or heavy rains, to preserve the integrity of the current.

Besides the supporting-posts, there are others called 'winding-posts,' four to the mile, to which the wires are connected in alternate half-mile lengths, and stretched by means of a screwing apparatus. It is on these posts that the stone collars are used; a sufficient number being attached to each side, the wire is passed through the eye and drawn tight, while to maintain the communication uninterrupted, a loop of wire is affixed to the main lengths at a short distance on either side of the post, round the front of which it passes in a slight curve. To protect the insulators as much as possible from wet, they are sheltered by a sloping wooden roof. The pointed wire seen rising a few inches above the tops of the posts on some lines is a lightning-conductor with its lower extremity buried in the earth. A precaution not unnecessary, as thunder-storms produce singular effects on the lines of telegraph.

One wire only will suffice for the transmission of correspondence between any two places; the making use of a greater number, six, eight, or ten, as may be seen on some railways, is merely for the sake of economy or convenience. It is found better in practice to keep one or two wires distinct for the main termini or points of correspondence—say from London to Derby—than to make them serve at the same time all the intermediate stations. It is an arrangement which helps to simplify the working duties of the office, and to facilitate them also, for with but one or two wires there would be constantly-recurring delays and confusion, since while any two places were intercommunicating all the others would have to wait. One of the wires is sometimes employed exclusively for the alarums—that is, to ring the bell at any station with which it may be desired to 'speak.' Wherever connection is made with an intermediate office, the main wire is cut, and a shackle inserted, and from either side of this a short wire is stretched to the instrument; thus affording means for the passage of a current up or down the line. The same contrivance would be adopted were there but one wire to connect the two extremes of the line; and it is within the bounds of possibility that some invention or adaptation will shew that all the required services may be performed by a single conductor.

The wires, when in their place, are connected with the batteries and telegraphic instruments at the respective stations; and here it becomes necessary to consider the construction and mode of action of a battery. The latter may be familiarly described as a wooden trough, from two to three feet long and about six inches wide, divided crosswise into twenty-four compartments or cells—more or fewer according to circumstances—by partitions of slate. Two plates of metal, copper and zinc alternately, are placed in each cell, in such an order that all the plates of one kind face towards one end of the trough, and all of the other kind to the other end. A small strip or ribbon of copper unites each pair at the centre of their upper edges, forming, as it were, so many curved handles, by which they can be lifted in and out. As soon, then, as the remaining vacant space in each cell is filled with an acidulated fluid the action commences; the acid begins to act on the zinc by dissolving it, the water contained in the solution is decomposed, and hydrogen thrown off from the surface of the copper plates; while by a combination of oxygen, oxide of zinc is formed, and this, dissolving in the acid—which is commonly sulphuric—sulphate of zinc is produced. These effects are the consequence of the general law established in relation to voltaic electricity, 'that by the simple contact of dissimilar metallic bodies, a partial transfer of the electric fluid from one to the other invariably takes place.' A positive current is generated at the zinc, and passes to the copper through the intervening fluid in all the series of cells; and continues to flow as long as contact is maintained between the wires which depart from either end, whatever be their length. There are various contrivances for increasing and rendering continuous the power of batteries, and for checking deterioration in the metal or acid, which we need not stay to consider, as they do not affect the main question.

The cells of telegraph batteries, instead of a fluid, are filled with pure sand—a material chemically inert, moistened by pouring in the dilute sulphuric acid—an arrangement which admits of the apparatus being removed from place to place without risk of spilling the contents, while it diminishes waste of the plates without diminishing their power. The zinc is most liable to dissolution, and would be rapidly exhausted were it not for the protective influence discovered by Mr Sturgeon. Having washed the plates clean, he dipped them into mercury, and the thin adherent coat of the rarer metal is found to prevent effervescence of the surface. Those which are known as *amalgamated* plates consequently last longer than others left in their native state; and after a turn of service they may be again washed and redipped. A well-prepared battery, with occasional renewals of the acid, will maintain an effective working condition during twelve or fifteen months. According to Mr C. V. Walker, to whose work we are indebted for the substance of some of our details: 'The telegraphs on the South-Eastern Railway, of 180 miles and forty-seven stations, are worked with 2200 pairs of such plates; and the whole telegraph system in the United Kingdom employs about 20,000 pairs.'

In preparing the batteries, it is possible to determine mathematically beforehand the amount of resistance, and the force necessary to overcome it; and thus to proportion the number of plates to the distance to which the wires extend. Large wires are better conductors than small ones. Iron is a better conductor than copper, and copper than silver. The several conditions may be calculated from the formulæ laid down by Ohm.

The wires of the battery meet those of the telegraph in what is called the electro-magnetic machine, which externally resembles a cabinet clock, having a square dial-plate inscribed with the letters of the alphabet, and certain arbitrary characters, and two hands placed side by side near its centre. These hands are the needles which are the tongues of the apparatus; in their vibrations to the right and left, their starts and pauses, the whole correspondence is conveyed. For each needle visible on the face of the instrument there is a corresponding one inside, the two being so placed that the north pole of the one and the south pole of the other are in the same position, so as to neutralise their magnetism, or rather the action of magnetism upon them. They are thus kept in a perpendicular position, and obedient to the slightest impulse from the battery. The inner needle is suspended within a coil or multiplier, which intensifies the power of the current at this particular spot, and is deflected to either side at pleasure by movement of the levers or handles which close or open the electro-magnetic circuit.

The telegraph wires finish in two terminals, which form part of the mechanism, and are in connection with the magnet and the multiplier. The battery wires are brought to two other terminals, connected also with the same apparatus; so that in order to reach the telegraph wires, the current must first excite the magnet and the needles. This action takes place only when work is to be done; at other times the circuit is left open. Instantaneously, however, on making contact, the signals exhibited at one end of the line are reproduced at the other; such is the astonishing power of the magnet when rendered active. Messages of business or friendship, congratulation or anxiety, may be sent from one end of the kingdom to the other with the velocity of lightning; on which Arago observes, 'the most extended and brilliant flashes of the first and second order, those even which appear to develop their fires over the whole scope of the visible horizon, are not equal in duration to the thousandth part of a second.'

With all this speed, however, there is no actual motion, no absolute passage of a fluid. It is only that. by a law of polarity, one molecule affects the other next to it; and so on *ad infinitum*, and with almost inappreciable celerity, as long as the exciting cause remains. To demonstrate the invisible by the visible, we may compare it to the great tidal wave which comes up from the South Atlantic at the rate of a thousand miles an hour. Such a mass with such rapidity, it is evident, would instantly overwhelm and destroy the mightiest barriers, and continents would be swept away as fragile mounds. But it is not the water that moves; the original impulse or motion, travelling from particle to particle, alone produces the phenomenon. So with what is called a current of electricity along a conducting body.

When a message is to be sent, the clerk whose duty it is to work the instrument, places the written document before him; and after striking the 'ringing key,' to call the attention of his correspondent, takes one of the levers which project from the base of the machine in each hand, and moving them from side to side produces corresponding and simultaneous movements of the needles on his own and the distant dial-plate, and the words are spelt off with great facility. Such is the quickness of apprehension acquired by practice, that the clerks can write the message as fast as the needles deliver it; and it is said that some of the more expert would be able to read it without error from a blank dial.

To expedite transmission, the communications are made as brief as possible, by the elision of letters, and syllables, and sometimes of half a word; besides which, many conventional signs are made use of. 'We have,' says Mr Walker, 'a signal for the period or full stop, and for *paragraphs;* and we have one for *underlining* words. And we have many very valuable special signals. There is also a signal among the clerks for laughing, and one for the *whistle* of astonishment.' Where secrecy is desired, any two parties have only to agree to employ numerals as letters, or to reverse or transpose the alphabet at pleasure, in order to form a code of signals which none but themselves shall be able to interpret. The messages transmitted on the Admiralty service are based on a private system, of which the chiefs alone understand the import.

With respect to communications of greater length, the writer just quoted observes: 'The rates at which newspaper dispatches are transmitted from Dover to London, is a good illustration of the perfect state to which the needle-telegraph has attained, and of the apt manipulation of the officers in charge. The mail, which leaves Paris about mid-day, conveys to England dispatches containing the latest news, which are intended to appear in the whole impression of the morning paper. To this end it is necessary that a copy be delivered to the editor in London about three o'clock in the morning.

The dispatches are given in charge to us at Dover soon after the arrival of the boat, which of course depends on the wind and the weather. The officer on duty at Dover, having first hastily glanced through the manuscript, to see that all is clear to him and legible, calls 'London,' and commences the transmission. The nature of these dispatches may be daily seen by reference to the 'Times.' The miscellaneous character of the intelligence therein contained, and the continual fresh names of persons and places, make them a fair sample for illustrating the capabilities of the electric telegraph as it now is. The clerk, who is all alone, placing the paper before him in a good light, and seated at the instrument, delivers the dispatch, letter by letter, and word by word, to his correspondent in London; and although the eye is transferred rapidly from the manuscript copy to the telegraph instrument, and both hands are occupied at the latter, he very rarely has cause to pause in his progress, and as rarely also does he commit an error. And, on account of the extremely limited time in which the whole operation must be compressed, he is not able, like the printer, to correct his copy.

'At London there are two clerks on duty—one to read the signals as they come, and the other to write. They have previously arranged their books and papers; and as soon as the signal for preparation is given, the writer sits before his manifold book, and the reader gives him distinctly word for word as it arrives; meanwhile a messenger has been despatched for a cab, which now waits in readiness. When the dispatch is completed, the clerk who has received it reads through the manuscript of the other, in order to see that he has not misunderstood him in any word. The hours and minutes of commencing and ending are noted; and the copy being signed, is sent under official seal to its destination, the manifold fac simile being retained as our office copy, to authenticate verbatim what we have delivered.'

'On 11th December 1849, to the great astonishment of the merchants and bankers of Paris, three gentlemen appeared on 'Change in that city, at half-past one P.M., having with them 150 copies of the 'Times,' printed and published in London on the morning of the self-same day; and not only did the 'Times' contain the Paris news up to noon of the previous day, but actually the closing prices of the Paris Bourse of the previous evening.

'The electric telegraph contributed in no small degree towards the accomplishment of this feat. At eight minutes past one A.M., the dispatch of 321 words, and the Bourse prices, equal to 55 words, were delivered into our charge at Dover, having been conveyed thither from Calais in the ordinary mail-boat. In exactly thirty-two minutes—namely, at forty minutes past one—a correct copy of both these documents was handed in by us to the Times Office in London. The dispatch occupied us eighteen minutes, being at the rate of 17⅚ words per minute; the Bourse prices, two minutes. In respect to the latter, the rate is high, because the larger portion is anticipated, the mere fluctuations being all that is new. There was nothing extraordinary to us in this, quickly as it was accomplished; indeed, on the following morning the writer in London was fairly beaten by the telegraph—the words were read off faster than he could make a clean copy of them.'

An idea of the amount of telegraphic correspondence on a railway may be formed from the fact, that on the South-Eastern line, 'during the three months ending October 17, 1850, 4831 service messages were entered in the Tonbridge books, and 5235 in those at Ashford.' And in six months of the same year the profits arising from the telegraph were £776, being at the rate of 5 per cent. per annum, and an increase of 1½ per cent. over the corresponding six months of 1849.

The proprietors of telegraphs inform us that the communications intrusted to them for delivery comprise the whole catalogue of human wants and wishes, business and pleasure, joy and sorrow, friendship and law. On some occasions they have been asked to send a sum of money, or a small parcel along the wire, by individuals, too, whose surprise shewed the sincerity of their belief that the instrument could perform what was desired. Games of chess have been played between parties in distant towns—Southampton and London—the moves being flashed from place to place alternately, as fast as they were made. Then the security which the telegraph lends to railway travelling is not the least of its merits: accident and obstruction can at once be made known, and the remedy provided. 'On New-Year's Day 1850, a catastrophe, which it is fearful to contemplate, was averted by the aid of the telegraph. A collision had occurred to an empty train at Gravesend; and the driver having leaped from his engine, the latter started alone at full speed to London. Notice was immediately given by telegraph to London and other stations; and while the line was kept clear, an engine and other arrangements were prepared as a buttress to receive the runaway. The superintendent of the railway also started down the line on an engine; and on passing the runaway he reversed his engine, and had it transferred at the next crossing to the up-line, so as to be in the rear of the fugitive. He then started in chase, and on overtaking the other he ran into it at speed, and the driver of his engine took possession of the fugitive, and all danger was at an end. Twelve stations were passed in safety; it went by Woolwich at fifteen miles an hour, and was within a couple of miles of London before it was arrested. Had its approach been unknown, the mere money-value of the damage it would have caused might have equalled the cost of the whole line of telegraph.'

The promptitude with which detection has followed fraud by the agency of the telegraph is sometimes rather amusing. Mr Smee relates an instance: 'One Friday night, at ten o'clock, the chief cashier of the bank received a notice from Liverpool, by electric telegraph, to stop certain notes. The next morning the descriptions were placed upon a card and given to the proper officer, to watch that no person exchanged them for gold. Within ten minutes they were presented at the counter by an apparent foreigner, who pretended not to speak a word of English. A clerk in the office who spoke German interrogated him, when he declared that he had received them on the Exchange at Antwerp six weeks before. Upon reference to the books, however, it appeared that the notes had only been issued from the bank about fourteen days, and therefore he was at once detected as the utterer of a falsehood. The terrible Forrester was sent for, who forthwith locked him up, and the notes were detained. A letter was at once written to Liverpool, and the real owner of the notes came up to town on Monday morning. He stated that he was about to sail for America, and that whilst at an hotel he had exhibited the notes. The person in custody advised him to stow the valuables in his portmanteau, as Liverpool was a very dangerous place for a man to walk about with so much money in his pocket. The owner of the property had no sooner left the house than his adviser broke open the portmanteau and stole the property. The thief was taken to the Mansion-House, and could not make any defence. The Sessions were then at the Old Bailey. Though no one who attends that court can doubt that impartial justice and leniency are administered to the prisoners, yet there is no one who does not marvel at the truly railway-speed with which the trials are conducted. By a little after ten the next morning—such was the speed—not only was a true bill found, but the trial by petty-jury was concluded, and the thief sentenced to expiate his offence by ten years' exile from his native country.'

The Electric Telegraph Company, incorporated in 1846, whose central establishment is in Lothbury, behind the Bank of England, hold a patent right for a term, in part expired, of fourteen years; their charge for the use of it is £20 per mile. The building is amply furnished with all the requisites for telegraph service; and by means of wires laid in tubes under the surface of the streets, is connected with all but one or two of the metropolitan railway stations, the post-office, the head police station in Scotland Yard, the Admiralty, the new Houses of Parliament, Buckingham Palace, and the latter, by a further extension, are now placed in communication with the Great Exhibition Building in Hyde Park. Besides these, communications are complete with eighty different places in the provinces, including the chief towns and outports. Electric telegraphs, according to the parliamentary enactment, 'shall be open for the sending and receiving of messages by all persons alike, without favour or preference, subject to a prior right of use thereof for the service of Her Majesty, and for the purposes of the company.' A proviso is also made in favour of the secretary of state, who may, on extraordinary occasions, take possession of all the telegraph stations, and hold them for a week, with power to continue the occupation should the common-weal require it. 'There have now,' so runs the company's official circular, 'been established in Edinburgh, Manchester, Liverpool, Glasgow, Hull, and Newcastle, Subscription News Rooms, for the accommodation of the mercantile and professional interests, to which is transmitted by electric telegraph the latest intelligence, including—domestic and foreign news; shipping news; the stock, share, corn, and other markets; parliamentary intelligence; London Gazette; state of the wind and weather from above forty places in England; and the earliest possible notices of all important occurrences.' The 'rate of charges for twenty words is—1d. per mile for the first 50 miles; ½d. for the second 50; and ¼d. for any distance beyond 100 miles.' The lowest charge made is half-a-crown. From London to York for twenty words, the cost would be 9s.; to Edinburgh, 13s.; to Glasgow, 14s.; and to other places in proportion. The number of miles of telegraph in Great Britain at the present time is about 3000, which leaves about 4000 miles of railway unprovided for.

During the last session of parliament a second association was incorporated, to be known as the British Electric Telegraph Company, 'for the purpose of telegraphic communication upon a more economical scale throughout the country, and for the purchase and use of patents.' The company's central office is at the Royal Exchange; they propose to conform to the American tariff of charges for the delivery of messages; to sell licences; and establish lines to all the chief towns in the kingdom. One of their projects is to connect Dublin with Belfast, and to cross the Channel from the latter town to Scotland: when completed, the capitals of the three kingdoms will be able to intercommunicate at any moment. And the reduction of charge which may be anticipated from the competition will, it is to be presumed, bring the telegraph more than at present within the means of the general public.

The spread of electric telegraphs in France has been extremely slow: for a long time the government refused to abandon their well-developed system of aerial telegraphs; and when with much reluctance they were induced to avail themselves of the infinitely superior agency of electro-magnetism, they stipulated that the signals should still be produced by small instruments, counterparts on a diminutive scale of the apparatus contrived by Chappe. There were, however, too many practical difficulties in the way, and ultimately the absurd condition was withdrawn in favour of machinery similar to that used in this country, the government reserving to itself the exclusive use and control of the lines. In 1845 and two following years, the telegraphs extending from Paris to Orleans, to Rouen, to Lille and Calais, and the Belgian frontier, and to Versailles, were commenced, and brought into operation. The results were such, that in January 1850 a commission was appointed to inquire further into the subject.

They drew up a favourable report, recommending the formation of additional lines, and the plan of stretching the wires on posts in preference to placing them in tubes underground, and that the telegraphs should be open to the use of the public. Among other economical advantages to result from the further extension, was the saving of locomotive power on railways; for, in accordance with the practice on the French lines, whenever a train was twenty minutes late an assistant-engine was despatched to its relief from one station after another all along the route—an arrangement which not only involved considerable expense, but liability to accident also. The construction of seven telegraphic lines was recommended; five of the number have been officially authorised—from Paris to Tonnerre, Rouen to Havre, Paris to Angers, Orleans to Châteauroux, and from the same city to Nevers; and by a vote of the Assembly, 717,095 francs are set apart to defray the expenses of the necessary works. To afford the fullest facilities to the government, wires are led from the respective stations in Paris to the hotel of the Minister of the Interior, where the office is now open to the public from 8 A.M. to 9 P.M. every day without exception. Three hundred and one dispatches were transmitted in March, the first month of opening. According to the scale of charges — to send a message of twenty words 62½ miles will cost 3s. 3½d., and 12s. for 620 miles. Two hundred words for the same distances respectively will be 16s. 5d. and 58s. 9d. At this rate, to send a message of 300 words from Paris to Calais (185 miles) would cost more than 35s. The commission state, that from seventy-five to eighty letters may be transmitted per minute. In the course of their report they suggest, that as the line from the capital to Dunkerque is on the meridian of Paris, and one of the points of the great survey for the measurement of an arc of the meridian some fifty years ago, the establishment of an electric telegraph will afford an excellent opportunity for testing the former by remeasurement. The telegraphs complete and in progress in France are about 1500 miles in length.

In Belgium, a commission was also appointed at the close of 1849 to consider the same subject: the individuals named—one of them being M. Quetelet—were eminently qualified for their duties. After a careful examination of the systems of electro-telegraphic communication employed in other countries—the burying of the wires under ground, as in Prussia, and the stretching of them on posts, as in England and the United States—the liability to accident from premeditated mischief, atmospheric or other causes—they have decided in favour of wires above rather than below the earth. They shew that the disturbances to which the apparatus is liable from electricity of the air is nowhere so effectually guarded against as in England, where conductors are attached to the posts and to the machinery in the offices, and recommend the adoption of similar means of protection on the Belgian lines, which they propose to establish from Brussels to Quiévrain—and to the Prussian frontier; from Malines to Ostend by way of Ghent—and to Antwerp—the several distances amounting to about 300 miles. They estimate the annual receipts and savings from these various sources at 86,000 francs; and acting on their report, the government has granted a credit of 250,000 francs for carrying the projects into execution. The central situation of Belgium with regard to other countries renders the formation of these lines of essential importance in continental communications.

Already the ramifications of electro-telegraphs extend from one end of Europe to the other: the lines to connect Petersburg with Moscow, and with the Russian ports on the Black Sea and the Baltic, are in progress; other wires stretch from the capital of the czar to Vienna and Berlin, taking Cracow, Warsaw, and Posen on the way. Two lines, by different routes—Olmutz and Brunn—unite Vienna with Prague, from whence an offset leads to Dresden; a third enables the Austrian government to send messages to Trieste—their outport on the Adriatic—325 miles distant; a fourth communicates with the metropolis of Bavaria; and 'since the 10th January (1850), the "Gazette d'Augsburg" has published the course of exchange in Munich twenty minutes after it has been declared in Vienna.' Calais may send news to the city of the Magyar on the Danube; and erelong intelligence will be flashed without interruption from St Petersburg to the Pyrenees. Tuscany has 100 miles of telegraph under the direction of Signor Matteucci; and a single wire, traversing the level surface of the Netherlands, unites Rotterdam with Amsterdam. Communities are learning that the electric telegraph is an essential of good government; that police without it is inefficient; that by it the better interests of humanity are promoted. There is talk also of introducing the thought-flasher into that land of wonders—Egypt; to stretch a wire from Cairo to Suez for the service of the overland mail. Who shall say that before the present generation passes away, Downing Street may not be placed in telegraphic *rapport* with Calcutta?

In Austria there are about 3000 miles of telegraph, one-fourth being gutta-percha-coated wire laid underground. Germany has 2500 miles complete, and 1200 more in process of construction. The Austrian government steamboats are fitted with an electric telegraph for communications from the captain on deck to the engine-room.

In a time when mechanical science scarcely admits the signification of 'impossible,' the insular position of England would not long shut her out from a union with those continental ramifications which we have briefly noticed. The possibility of establishing the connection was satisfactorily proved in August 1850, when a telegraph-wire was sunk across the Channel from Dover to Cape Grisnez, on the French coast. On the 28th of that month, after certain preliminary experiments had been tried, the *Goliah* steamer started with a huge reel containing 25 miles of wire, coated with gutta percha, on her deck, which was slowly unwound and submerged as she left the land. A horse-box was set up on the beach, to serve as a temporary office for the instruments and operators; from which the wire was led through a lead pipe to some distance beyond low-water mark, as a measure of protection in a part the most exposed. A line of buoys marked the track of the steamer; she travelled about four miles an hour, and the wire was gradually sunk at the same rate by means of heavy weights attached at regular intervals. A powerful set of batteries had been provided, as one of the objects was, if possible, to work Brett's printing telegraph; and when the steamer had made good a portion of her voyage, the communication was established, and words were printed at the instrument on board the vessel—imperfectly, it is true; but the fact once verified, the perfecting becomes matter of detail. The needle instrument played freely, and in the evening its signals shewed that the voyage had terminated successfully. A message flashed from under the sea by the opposite party announced, 'We are all safe at Cape Grisnez,' with the inquiry added, 'How are you?' Thus the international communication was complete; but soon after interrupted by the breaking of the wire, which was too weak to withstand the action of the water and friction on a rocky bottom.

As before observed, the possibility having been proved, the Submarine Telegraph Company, whose patent embraces England, France, and Belgium, set about preparations to re-establish the connection, on a scale calculated to obviate the risk of accident. The wires, four or five in number, are to be enclosed in cables several inches in thickness, and from twenty to twenty-five miles in length, each weighing 400 tons. It is proposed to have three or four such cables, to be anchored to the bottom two or more miles apart, so that if one should fail, communication may still be maintained by the others. Expectations are held out that the line may again be brought into working order during the present year (1851.)

It is in the United States of America that the electric telegraph has been most extensively developed and applied. Growing coincidently with the system so successfully worked in our own country, an almost limitless breadth of territory has necessitated a proportionate extension of the wires, amounting at present to more than 11,000 miles, under the management of twenty-two companies. The lines in many instances are carried across the country, regardless of travelled thoroughfares; over tracts of sand and swamp; through the wild primeval forest, where man has not yet begun his contest with nature—where even the rudiments of civilisation are yet to be learned. Away it stretches, the metallic indicator of intellectual supremacy, traversing regions haunted by the rattlesnake and the alligator—solitudes that re-echo with nocturnal howlings of the wolf and bear. Economy and rapidity of construction are prime desiderata in America; and to insure the proper working of the telegraph in its direct course across the country, the settlers who live near the line are permitted to make use of it on condition that they keep it in repair. By this means communications are maintained from north to south, east and west, through all the length and breadth of the mighty Union, and with a frequency and social purpose exceeding that of any other nation. From the frontiers of Canada at Burlington, and from Halifax in Nova Scotia, a line passes to Boston, and thence in a southerly direction till it reaches the Gulf of Mexico at New Orleans—a distance of 2600 miles. It connects all the great cities of the Atlantic coast—New York, Philadelphia, Baltimore, Washington, Richmond in Virginia, Raleigh and Columbia in South Carolina, Augusta in Georgia, and Mobile in Alabama. In one stretch Maine and Vermont, where winter with deepest snows and arctic temperature usurps six months of the year, are united with the lands of the tropics, where the magnolia blooms and palm-trees grow in perpetual summer. From New Orleans another nerve of wire, more than 1000 miles long, threads the valleys of the Mississippi and Ohio to Louisville and Cincinnati; and subordinate lines bring the great lakes—the inland seas—into direct communication with the ocean-ports on the eastern shore. In some instances the rivers are spanned by wires stretched on tall poles, or laid in tubes of gutta percha along the bottom of the wider channels or estuaries. Nothing stops the restless, enterprising spirit of the people; and their project for uniting the Atlantic with the Pacific, New York with San Francisco, may be considered as far from visionary.

The scale of charges in the United States is much lower than in this country: the electric telegraph is consequently more available to the greater part of the population engaged in commercial affairs. A message of ten words may be flashed from New York to St Louis, Missouri, for 1 dollar and 40 cents—each additional word being charged 3 cents; to Cincinnati, 75 cents; to Buffalo, 500 miles, 40 cents; to Boston, 220 miles, 20 cents; to New Orleans, 2½ dollars; and other places in proportion. The transmitting apparatus used on the different lines is that severally invented or contrived by Morse, House, and Bain; it prints the dispatches as fast as they are delivered. On the meeting of the legislature at Albany in 1847, the governor's message, 25,000 letters, was flashed to New York, 150 miles distant, and printed at the same time in two hours and a half. The president's message, too, on the war with Mexico, was transmitted from Washington to Baltimore, 40 miles, and permanently recorded at the rate of ninety-nine letters a minute. Mr Morse in his Reports to Congress mentions several instances of the utility of the telegraph. During the popular disturbances at Philadelphia in 1844, 'sealed dispatches were sent by express from the mayor of Philadelphia to the president of the United States. On the arrival of the express at Baltimore, the purport of the dispatches transpired; and while the express train was in preparation, the intelligence was sent on to Washington by telegraph, accompanied by an order from the president of the railroad company to prevent the burden-train from leaving until the express should arrive. The order was given and complied with. The express had a clear track, and the president and cabinet (being in council) had notice both of the fact, that important dispatches were on the way to them, and of the nature of those dispatches; so that when the express arrived, the answer was in readiness for the messenger.' Again: 'When the *Hibernia* steamer arrived at Boston in January 1847, with news of the scarcity in Great Britain, Ireland, and other parts of Europe, and with heavy orders for agricultural produce, the farmers in the interior of the state of New York, informed of the facts by magnetic telegraph, were thronging the streets of Albany with innumerable team-loads of grain almost as quickly after the arrival of the steamer at Boston as the news of that arrival could ordinarily have reached them.'

Apart from business and politics, the Americans have made the electric telegraph subservient to other uses: medical practitioners in distant towns have been consulted, and their prescriptions transmitted along the wire; and a short time since a gallant gentleman in Boston married a lady in New York by telegraph—a process which may supersede the necessity for elopement, provided the law hold the ceremony valid. Music, or at least the rhythm of music, has been conveyed by the same wonderful agency. The observer of the fact in New York tells us: 'We were in the Hanover Street office when there was a pause in business operations. Mr W. Porter of the office at Boston asked what tune we would have. We replied 'Yankee Doodle,' and to our surprise he immediately complied with our request. The instrument commenced drumming the notes of the tune as perfectly and distinctly as a skilful drummer could have made them at the head of a regiment; and many will be astonished to hear that 'Yankee Doodle' can travel by lightning. We then asked for 'Hail Columbia!' when the notes of that national air were distinctly beat off. We then asked for 'Auld lang syne,' which was given, and 'Old Dan Tucker,' when Mr Porter also sent that tune, and, if possible, in a more perfect manner than the others. So perfectly and distinctly were the sounds of the tunes transmitted, that good instrumental performers could have had no difficulty in keeping time with the instruments at this end of the wires.'

A favourable idea of the immediate practical utility of the telegraph may be gathered from a communication to the present writer by a friend in New York:—'The telegraph,' he writes, 'is used in this country by all classes, except the very poorest—the same as the mail. A man leaves his family for a week or a month; he telegraphs them of his health and whereabouts from time to time. If returning home, on reaching Albany or Philadelphia, he sends word the hour that he will arrive. In the towns about New York the most ordinary messages are sent in this way: a joke, an invitation to a party, an inquiry about health, &c. In our business we use it continually. The other day two different men from Montreal wanted credit, and had no references; we said: "Very well; look out the goods, and we will see about it." Meanwhile we asked our friends in Montreal—"Are Pump and Proser good for one hundred dollars each?" The answer was immediately returned, and we acted accordingly; probably much to our customers' surprise. The charge was a dollar for each message, distance about 500 miles, but much further by telegraph, as it has to go a round to avoid the water. If my brother goes to Philadelphia, he telegraphs, "How is the family?" "What is doing?" I answer: "All well"—"Sales so much;" and so on to the end of the chapter.

'A good deal of our telegraph was put up slightly at first, and was often destroyed by storms. Now it is made with heavier wire, on posts from eight to twelve inches diameter. The lines cross the North River (the Hudson), suspended from the top of a very high pole on each side, placed on the top of the hills. The wire goes over at one stretch; the distance about a mile, but still hanging high enough in the centre to allow the tallest ships to pass under it. At the offices they are accommodating, and will inquire about messages that have miscarried, or have not been answered, without extra charge.'

The electric clock was an obvious result of the electric telegraph: a plate of zinc and another of copper buried in the earth, and connected by wires with the wheelwork, develop sufficient natural magnetism to keep a timekeeper going with the strictest regularity for several years. As the pendulum swings, contact is alternately made and broken, and this action will continue until the plates are exhausted. With currents supplied from a battery, it is clear that the movement may become perpetual; and by means of telegraphic communications, any number of clocks may be made to move synchronously with one central clock regulated by astronomical observation; each would advance a second or portion of a second at one and the same beat. The invention of this remarkable machine is due to Mr Wheatstone, who proposed it to the Astronomical Society ten years ago, when the wide applicability of the principle gave rise to the remark, that it would soon become as possible to have time 'laid on' to our houses as water or gas. One possibility suggests another, and presently we find the Americans making use of the electric telegraph to determine differences of longitude. Supposing the time-keeper of the Greenwich Observatory in communication with a clock at Edinburgh, the latter would beat Greenwich time, whereby the difference between the two places would be determined to the fraction of a second. The means of intercommunication being so rapid, comparisons can be instituted to any extent, and the severest tests applied to insure accuracy; and by the aid of the printing apparatus, the observations are recorded at the precise instant of their occurrence. The first experiment was tried along the telegraph from Cincinnati to Pittsburg, by Dr Locke of the former city, who contrived some ingenious machinery for the purpose. We are informed that 'it was eminently successful, and the registering of the seconds of time on the running fillet of paper was continued for two hours at all the offices along the line, much to the astonishment of the operators.' The officer of the United States Coast Survey regards 'the value of a night's work with a transit instrument by the printing method, as about ten times greater than by the method now in use among astronomers.' In the Report for 1848 we read: 'This year we made abundant experiments on the line from Philadelphia to Louisville, a distance in the air of 900 miles, and in circuit of 1800 miles. The performance of this long line was better than that of any of the shorter lines has hitherto been.

'Not more than two or three good astronomical nights, at Cincinnati and Philadelphia, were lost, by failure of any part of the line, in the period of two months nearly of our stay at Cincinnati. I learn from an authentic source that the same success attends the work from Philadelphia to St Louis, a distance of circuit one-twelfth of the earth's circumference.' Great as this distance is, an attempt is to be made to exceed it as soon as circumstances permit, on the line from Halifax to New Orleans, in determinations of longitude.

This method of observing is regarded by the astronomer-royal as of so much importance, that he proposes to introduce it at Greenwich. In discussing the subject before the Astronomical Society, he explained that: 'In ordinary transit observations, the observer listens to the beat of a clock while he views the heavenly bodies passing across the wires of the telescope; and he combines the two senses of hearing and sight (usually by noticing the place of the body at each beat of the clock) in such a manner as to be enabled to compute mentally the fraction of the second when the object passes each wire, and he then writes down the time in an observing-book. In these new methods he has no clock near him, or at least none to which he listens: he observes with his eye the appulse of the object to the wire, and at that instant he touches an index, or key, with his finger; and this touch makes, by means of a galvanic current, an impression upon some recording apparatus (perhaps at a great distance), by which the fact and the time of the observation are registered. He writes nothing, except perhaps the name of the object observed.'

The experience hitherto obtained of the new method shews that in what are termed 'irregularities' in observation, the amount 'is only about one-fourth' of that which occurs in the old method; whether because the sympathy between the eye and the finger is more lively than between the eye and the ear, remains to be determined. The astronomer-royal proposes to use the 'centrifugal or conical-pendulum clock' as an instrument superior in every way to those used in America; and 'considering,' as he states, 'the problem of smooth and accurate motion as being now much nearer to its solution than it had formerly been, it might be a question whether, supposing a sidereal clock made on these principles to be mounted at the Royal Observatory, it should be used in communicating motion to a solar clock. It might by some persons be thought advantageous, even now, that the drop of the signal-ball (at one hour Greenwich mean solar time) should be effected by clock machinery; and it is quite within possibility that a time-signal may be sent from the Royal Observatory to different parts of the kingdom at certain mean solar hours every day, by a galvanic current regulated by clock machinery.' We may add that at Boston, U. S., the true time is received every day from the Cambridge observatory, four miles distant, for the service of the shipping in the harbour.

Meteorological, as well as astronomical science, is also to be promoted by means of the telegraph, and with benefit to life and property. Vessels about to sail from the northern to the southern ports of the United States are now detained when news arrives of a storm or tornado having broken out in the lower latitudes; and in our own country the state of the weather is communicated every day from stations in all parts of the kingdom to one central office, where the returns are published. Many valuable results have already been obtained; and with further experience in working out the system, it will prove directly and practically advantageous.

The disturbances to which the electric telegraph is liable from atmospheric and other causes, present several phenomena of interest to the scientific observer. During thunder-storms the needles are sometimes violently agitated, or altogether deprived of their electricity; and the influence of the earth's magnetism is frequently such as to cause considerable deflections, even where the wires are under ground. Mr Barlow of Derby, in an account of his experiments on this latter subject, published in the 'Philosophical Transactions,' states that a regular diurnal action of the needles is produced, independently of the batteries, on telegraph wires connected with the earth in two places: where not so connected, no deflection is observable. He considers, 'that this motion is due to electric currents passing from the northern to the southern extremities of the telegraph wires, and returning in the opposite direction; and that, exclusive of the irregular disturbances, the currents flow in a southerly direction from about 8 or 9 A.M. until the evening, and in a northerly direction during the remainder of the twenty-four hours.' Sometimes the perturbations are coincident all over the kingdom, as was the case on September 24, 1847, when sudden deflections of the needles occurred from Devonshire to Scotland, and were also observed in other parts of the world at the same time. The aurora, too, is another exciting cause. Mr Barlow believes that he can predict this phenomenon from the movements of the needles, and is supported in his views by other observers. According to De la Rive: 'The remarkable effect which M. Matteucci observed in the apparatus of the electric telegraph between Ravenna and Pisa, during the magnificent aurora of November last, shews clearly the existence of a current circulating upon the surface of the earth; and which, rising by the telegraph wire, passed partly by this better conductor. The sounds which are given in certain meteorological circumstances by long iron wires stretched in a north and south direction, are clear evidence that they are traversed by a current which probably arises from those which circulate upon the surface of the earth from north to south in our hemisphere. It would be very interesting to take advantage of telegraph wires having a direction more or less coincident with that of the declination of the needle, for the purpose of making, when they are not in use for their usual purposes, some observations to detect and measure the electric currents which probably traverse them—which could be easily done by completing the communication of these wires with the ground at one of their extremities by means of a multiplying galvanometer. The comparison of results thus obtained, with those of simultaneous observations of the diurnal variations of the magnetic needle, would certainly present much interest, and might lead to meteorological conclusions of a remarkable kind.' It is said that when telegraph lines are erected in India, some particularly interesting phenomena of terrestrial magnetism will be witnessed.

Our brief historical sketch offers another exemplification—and not among the least interesting—of the onward workings of the human mind. From timid and uncertain beginnings the electric telegraph has advanced to a high state of usefulness and perfection. Available alike for the humblest of social purposes, and the daring endeavours of science, it reaches a supereminent point when the measured flight of time, the movements of stars and planets, and investigations of atmospheric and magnetic mysteries, become the subject of its transcendental powers. In contemplating the nature and scope of the phenomena, we may say without irreverence that the sublime inquiry—'Canst thou send lightnings, that they may go, and say unto thee, Here we are?'—has, in one grand sense, been answered in the affirmative.

THE ELECTRIC TELEGRAPH.

Hark! the warning needles click,
Hither—thither—clear and quick.
Swinging lightly to and fro,
Tidings from afar they shew,
While the patient watcher reads
As the rapid movement leads.
He who guides their speaking play
Stands a thousand miles away.

Sing who will of Orphean lyre,
Ours the wonder-working wire!

Eloquent, though all unheard,
Swiftly speeds the secret word,
Light or dark, or foul or fair,
Still a message prompt to bear:
None can read it on the way,
None its unseen transit stay.
Now it comes in sentence brief,
Now it tells of loss and grief,
Now of sorrow, now of mirth,
Now a wedding, now a birth,
Now of cunning, now of crime,
Now of trade in wane or prime,
Now of safe or sunken ships,
Now the murderer outstrips,
Now it warns of failing breath,
Strikes or stays the stroke of death.

Sing who will of Orphean lyre,
Ours the wonder-working wire!

Now what stirring news it brings,
Plots of emperors and kings;
Or of people grown to strength
Rising from their knees at length:
These to win a state—or school;
Those for flight or stronger rule.
All that nations dare or feel,
All that serves the commonweal,
All that tells of government,
On the wondrous impulse sent,
Marks how bold Invention's flight
Makes the widest realms unite.

It can fetters break or bind,
Foster or betray the mind,
Urge to war, incite to peace,
Toil impel, or bid it cease.

Sing who will of Orphean lyre,
Ours the wonder-working wire!

Speak the word, and think the thought,
Quick 'tis as with lightning caught,
Over—under—lands or seas,
To the far antipodes.
Now o'er cities thronged with men,
Forest now or lonely glen;
Now where busy Commerce broods,
Now in wildest solitudes;
Now where Christian temples stand,
Now afar in Pagan land.
Here again as soon as gone,
Making all the earth as one.
Moscow speaks at twelve o'clock,
London reads ere noon the shock;
Seems it not a feat sublime,
Intellect hath conquered Time!

Sing who will of Orphean lyre,
Ours the wonder-working wire!

Flash all ignorance away,
Knowledge seeks for freest play;
Flash sincerity of speech,
Noblest aims to all who teach;
Flash till bigotry be dumb,
Deed instead of doctrine come;
Flash to all who truly strive,
Hopes that keep the heart alive;
Flash real sentiments of worth,
Merit claims to rank with Birth;
Flash till Power shall learn the Right,
Flash till Reason conquer Might;
Flash resolve to every mind,
Manhood flash to all mankind.

Sing who will of Orphean lyre,
Ours the wonder-working wire!

[No. 3]

CHAMBERS'S

PAPERS FOR THE PEOPLE.

ARCTIC EXPLORATIONS.

THE varied physical aspect of the globe offers as much to charm or awe the eye of man as to minister to his comfort and wellbeing. From the glowing heat and gorgeous vegetation of the torrid zone, we move through all gradations of climate and feature to the frigid regions of either pole, where perpetual ice and a depressed temperature present an extraordinary contrast to the lands of the sun: from intensest heat we pass to intensest cold; from the sandy deserts of the south to the icy deserts of the north. Yet there is as much in the frozen zone to impress and elevate the mind of the beholder as in the countries where nature displays herself in rich and exuberant loveliness. Beyond the seventieth degree of latitude not a tree meets the eye, wearied with the white waste of snow: forests, woods, even shrubs have disappeared, and given place to a few lichens and creeping woody plants which scantily clothe the indurated soil. Still, in the farthest north, nature claims her birthright of beauty; and in the brief and rapid summer she brings forth numerous flowers and grasses to bloom for a few days, until again blasted by the swiftly-recurring winter.

In these regions certain mysterious phenomena exhibit their most powerful effects: here is the point of attraction of the compass needle; and here the dipping needle, which lies horizontal at the equator, points straight downwards. Slowly, in its cycle of nearly two thousand years, this centre or pole of magnetic attraction revolves in obedience to laws as yet unknown. Two degrees farther towards the north is situated the pole of cold—a mystery like the former to science, but equally inciting to curiosity. If induction may be trusted, the pole of the earth is less cold than the latitudes 15° below it.

Round the shores and seas of the arctic regions ice ever accumulates: a circle of two thousand miles diameter is occupied by frozen fields and floes of vast extent, or piled high with hugest forms, awful yet fantastic as a dreamer's fancy. Mountain masses—

'Whose blocks of sapphire seem to mortal eye
Hewn from cerulean quarries in the sky,
With glacier battlements that crowd the spheres,
The slow creation of six thousand years,
Amidst immensity they tower sublime,
Winter's eternal palace, built by Time.'

Here the months are divided into long periods of daylight and darkness: for many weeks the sun sinks not below the horison; for three dreary months he appears not above it—

'And morning comes, but comes not clad in light;
Uprisen day is but a paler night.'

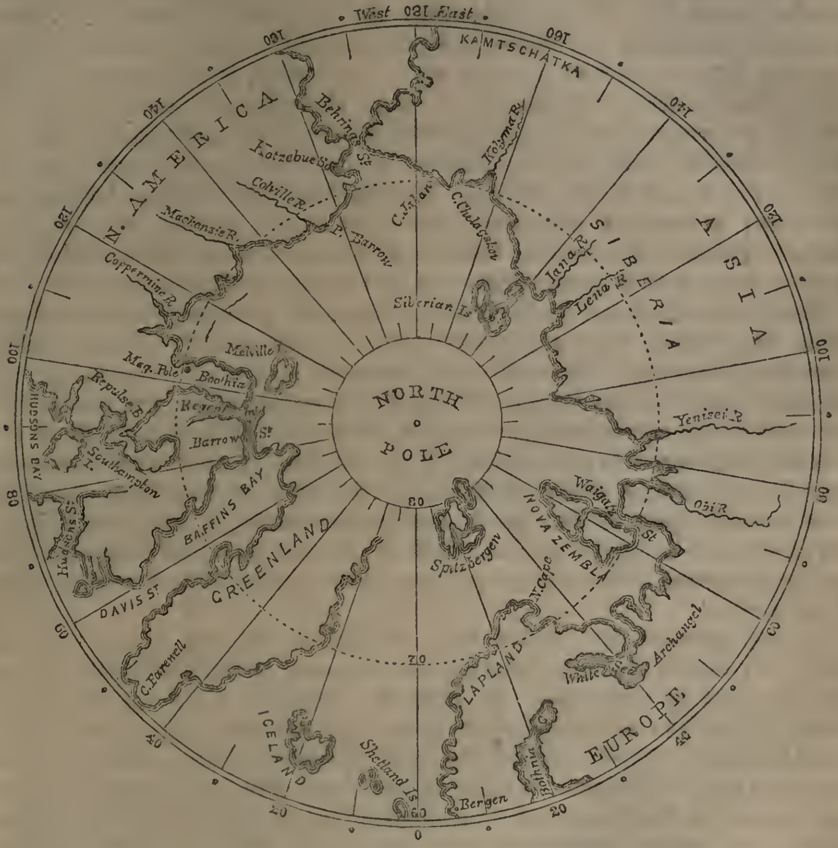
But, in the absence of the great luminary, the vivid coruscations of the aurora borealis illuminate the wintry landscape, streaming across the skies in broad sheets of light, flashing in multi-coloured rays, or quivering in faint and feathery scintillations—a light that takes away the irksomeness of gloom, and makes the long night wondrous.

The desolate grandeur of the scene is in many parts increased by the entire absence of animated nature; in others the dearth of vegetation is compensated by superabundance of animal life. Wrangell tells us that 'countless herds of reindeer, elks, black bears, foxes, sables, and gray squirrels, fill the upland forests; stone foxes and wolves roam over the low grounds. Enormous flights of swans, geese, and ducks arrive in spring, and seek deserts where they may moult and build their nests in safety. Eagles, owls, and gulls pursue their prey along the seacoast; ptarmigan run in troops among the bushes; little snipes are busy along the brooks and in the morasses; the social crows seek the neighbourhood of men's habitations; and when the sun shines in spring, one may even sometimes hear the cheerful note of the finch, and in autumn that of the thrush.'

'There is,' as observed by Lieutenant-Colonel Sabine, 'a striking resemblance in the configuration of the northern coasts of the continents of Asia and America for several hundred miles on either side of Behring's Strait; the general direction of the coast is the same in both continents, the latitude is nearly the same, and each has its attendant group of islands to the north—the Asiatic continent, those usually known as the New Siberian Islands—and the American, those called by Sir Edward Parry the North Georgian Group, and since fitly named, from their discoverer, the Parry Islands. The resemblance includes the islands also, both in general character and latitude.'

With respect to the Arctic Ocean, a late writer explains—'We may view this great polar sea as enclosed within a circle whose diameter is 40°, or 2400 geographical miles, and circumference 7200 miles. On the Asiatic side of this sea are Nova Zembla and the New Siberian Islands, each extending to about the 76th degree of latitude. On the European and American sides are Spitzbergen, extending to about 80°, and a part of Old Greenland, whose northern extremity is yet unknown. Facing America is the large island washed by Regent's Inlet, Parry's or

Melville's Islands, with some others, in latitude 70° to 76°, and beyond these nothing is known of any other land or islands; and if we may form an opinion, by inspecting the general chart of the earth, it would be, that no islands exist which could in any shape obstruct navigation.' It is to these regions, and the labours of which they have been the scene, that we have for a short period to direct our attention.



The history of Arctic explorations properly begins at a period earlier by several centuries than is generally believed. Careful researches promoted and carried on of late years by the Society of Northern Antiquaries of Copenhagen, and others interested in the subject, have established the fact, that Newfoundland, Greenland, and several parts of the American coast, were visited by the Scandinavians—the Northmen and Sea-Kings of old—in the ninth and tenth centuries. While Alfred was engaged in expelling the Danes from England, and bestowing the rudiments of civilisation on his country, and Charles the Bald was defending his kingdom against a host of competitors, the daring sea-rovers were forming settlements in Iceland. One hundred and twenty-five years later, A.D. 1000, Leif Erickson led the way to the westward, and landed on the shores of New England, between Boston and New York, naming the country Vinland, from the wild vines which grew in the woods. These adventurers made their way also to a high northern latitude, and set up stones, carved with Runic inscriptions, with the date 1135, on Women's Islands—in latitude 72° 55′—Baffin's Bay, where they were discovered in 1824. The colonists on the eastern coast of this great bay made regular trips to Lancaster Sound and part of Barrow's Strait in pursuit of fish 'more than six centuries before the adventurous voyage of Parry,' and carried on a trade with the settlers in Markland, as Nova Scotia was then called. Their numbers must have been considerable, for in Greenland there were three hundred homesteads or villages, and twenty churches and convents. They kept up intercourse with Europe until 1406, when it was interrupted by extraordinary accumulations of ice upon their coasts; and though the Danish government has made repeated attempts to ascertain their fate, it still remains in doubt; the supposition is, that all have perished from privation or violence of the natives. Spitzbergen, too, contained numerous colonists: graves are frequently met with on its shores; in one place Captain Buchan saw several thousands, the corpses in some of them as fresh as when first interred, preserved by the rigour of the climate.

These early explorers were unable to take full advantage of their American discoveries; this was reserved for a later period. 'Intervening,' observes Humboldt, 'between two different stages of cultivation, the fifteenth century forms a transition epoch, belonging at once to the middle ages and to the commencement of modern times. It is the epoch of the greatest discoveries in geographical space, comprising almost all degrees of latitude, and almost every gradation of elevation of the earth's surface. To the inhabitants of Europe it doubled the works of creation, while at the same time it offered to the intellect new and powerful incitements to the improvement of the natural sciences in their physical and mathematical departments.'

As we approach the period here referred to, we find a new spirit at work; no longer the boisterous adventurousness of the Northmen, but an earnest spirit of enterprise. In 1380, the Zeni, two Venetian navigators, voyaged into the north, ignorant of the fact, that the Scandinavians had preceded them by three centuries, and brought home accounts of the countries they had seen. Within eighty years after this event, the gulf and river of St Lawrence and Newfoundland were visited by the three Cortereals: the father returned to Portugal, but his two sons perished while endeavouring to extend his discoveries. In 1497, during the reign of Henry VII., British enterprise was first directed to a region in which it has been subsequently developed to a degree without example; and Cabot, or Cabota the younger, landed at Labrador eighteen months before Columbus saw the mainland of tropical America. He contemplated also a voyage to the pole, and sailed up to 67½° of north latitude. It was thought scarcely possible that the newly-discovered continent stretched so far from north to south without a single opening to the westward, and the search for this became the prime object with mercantile adventurers, who hoped to find a way to the rich and gorgeous countries lying beyond. Sir Hugh Willoughby was sent out by the Muscovy Company with two ships to find a north-east passage 'to Kathay and India;' and pushed his way as far as Nova Zembla, from whence, being stopped by ice, he returned to a lower latitude, and in September 1553 put in at the mouth of the river Arzina in Lapland. A melancholy interest attended this event, little anticipated by the unfortunate leader when he wrote in his journal—'Thus remaining in this haven the space of a weeke, seeing the yeare farre spent, and also very evill wether—as frost, snowe, and haile, as though it had beene the deepe of winter, wee thought it best to winter there.' The dreary season passed away, and in the following year some Russian fishermen found Sir Hugh and his crew all frozen to death. The other vessel, commanded by Richard Chancelor, reached Archangel, and opened the way for our commercial intercourse with Russia.

Next in importance are the three voyages by Frobisher in 1576–78. He discovered the entrance to Hudson's Strait, and explored that still known as Frobisher's; but failed in penetrating to the westward. Great hopes were excited by some lumps of yellow glistening ore which he brought home, and in his later voyages gold-mines were not less to be searched for than the north-west passage. The study of natural phenomena was not, however, altogether lost sight of, as appears by a passage from the instructions issued under the authority of Elizabeth for the gallant seaman's guidance. 'Yf yt be possible,' so runs the official document, 'you shall leave some persons to winter in the straight, giving them instructions how they may observe the nature of the ayre and state of the countrie, and what tyme of the yeare the straight is most free from yce; with who you shall leave a sufficient preparation of victualls and weapons, and also a pynnas, with a carpenter, and thyngs necessarie, so well as may be.' Then followed Sir Humphrey Gilbert's expedition to colonise Newfoundland: the fate of this 'devout gentleman and philosopher' has been touchingly narrated by a transatlantic poet—

'Eastward from Campobello
  Sir Humphrey Gilbert sailed;
Three days or more he seaward bore,
  Then, alas! the land-wind failed.

Alas! the land-wind failed,
  And ice-cold grew the night;
And never more, on sea or shore,
  Should Sir Humphrey see the light.

He sat upon the deck,
  The Book was in his hand;
"Do not fear! Heaven is as near,"
  He said, "by water as by land."'

The three voyages by Davis in 1585–88 enlarged the limits of research; by the discovery of the strait which still bears his name, he opened the way to Baffin's Bay and the Polar Sea; he also surveyed a considerable extent of the Greenland coast. Various attempts to find a passage were also made during this century by Spaniards, French, Danes, and Dutch; those of the last-mentioned nation being the most memorable. To avoid the risk of a voyage to India across the ocean, over which Spain claimed the supremacy, they sought for a shorter passage by the north-east.

The three voyages by William Barentz, 1594–96, afford striking examples of dangers encountered, and manful perseverance in struggling against them. He made his way to the sea between Spitzbergen and Nova Zembla, until, to quote the narrative of the third voyage, 'we came to so great a heape of ice, that we could not sayle through it.' In August of the last-mentioned year, the vessel was embayed by an unusual drifting of the ice, which, crushing around them with a violence that 'made all the haire of our heads to rise upright with feare,' forced them 'in great cold, povertie, miserie, and griefe, to stay all that winter.' They exerted themselves to the utmost to avoid so terrible an alternative; but on the 11th of September, as is related, 'we saw that we could not get out of the ice, but rather became faster, and could not loose our ship, as at other times we had done, as also that it began to be winter, we tooke counsell together what we were best to doe, according to the time, that we might winter there, and attend such adventure as God would send us; and after we had debated upon the matter (to keepe and defend ourselves both from the colde and wilde beastes), we determined to build a house upon the land, to keepe us therein as well as wee could, and so to commit ourselves unto the tuition of God.' While casting about for material for the edifice, to their great joy they discovered a quantity of drift timber, which they regarded as a special interposition of Providence in their behalf, and 'were much comforted, being in good hope that God would show us some further favour; for that wood served us not onely to build our house, but also to burne, and serve us all the winter long; otherwise, without all doubt, we had died there miserably with extreme cold.'

Parties were thereupon set to work to build the house, and drag their stores from the ship on hand-sleds, in which labours they were grievously interrupted by bears and severity of the weather: if any one held a nail between his lips, the skin came off with as much pain on taking it out again as though the iron had been red-hot; yet notwithstanding the cold, there was open sea for many weeks an 'arrow-shot' beyond their ship. The dwelling, slow in progress, was finished by the end of October, and thatched with sea-wrack, the more effectually to close the chinks in the roof and walls, and 'we set up our dyall, and made the clocke strike.' On the 4th November 'wee saw the sunne no more, for it was no longer above the horison; then our chirurgion made a bath (to bathe us in) of a wine-pipe, wherein wee entred one after the other, and it did us much good, and was a great meanes of our health.' All the spare clothing was distributed, regulations established with regard to diet, and duties apportioned; the master and pilot being exempted from cleaving wood, and other rude labours. Traps were set to catch foxes for food, and cheerfulness was as much as possible promoted; but at times they were snowed up, and could not open their door for many days, and had no light but that of their fire: they were tormented with smoke, while ice two inches thick formed in their sleeping-berths. The clock stopped with the cold, after which they could only reckon time by 'the twelve-hour glass.'

The misery they endured may be judged of by the tone of some of the entries in their journal; such suffering was but too frequent:—'It was foule weather againe, with an easterly wind and extreame cold, almost not to bee indured; whereupon wee lookt pittifully one upon the other, being in great feare that if the extreamitie of the cold grew to bee more and more, wee should all dye there with cold; for that what fire soever wee made it would not warme us; yea, and our sacke, which is so hot, was frozen very hard, so that when we were every man to have his part, we were forced to melt it in the fire, which we shared every second day about halfe a pint for a man, wherewith we were forced to sustayne ourselves; and at other times wee dranke water, which agreed not well with the cold, and we needed not to coole it with snow or ice; but we were forced to melt it out of the snow.' Sometimes, while they sat at the fire, 'and seemed to burne on the fore-side, we froze behind at our backes, and were all white as the countreymen use to bee when they come in at the gates of the toune in Holland with their sleds, and have gone all night.' It might indeed seem that no room remained for hope; yet under date December 19 we read, 'wee put each other in good comfort, that the sunne was then almost halfe over, and ready to come to us againe, which wee sore longed for, it being a weary time for us to bee without the sunne, and to want the greatest comfort that God sendeth unto man here upon the earth, and that which rejoyceth every living thing.' They kept Twelfth-Night also, and 'made pancakes with oyle, and every man a white bisket, which we sopt in wine: and so, supposing that we were in our owne countrey, and amongst our friends, it comforted us as well as if we had made a great banquet in our owne house: and wee also made tickets, and our gunner was king of Nova Zembla, which is at least 200 miles long, and lyeth between two seas.'

On the 24th January they saw the sun again, a sight that reanimated their sinking spirits, confined as they had been with no light but that of the fire, and often prevented by heavy snow from going out of their dwelling for many days in succession. Several of the party were sick—one died: a grave seven feet deep was dug in the snow; and then, as is mournfully recorded, 'after that we had read certaine chapters and sung some psalmes, we all went out and buried the man.' As the days lengthened, they set about preparations for departure, and repaired their two boats, and had good hope 'to get out of that wilde, desart, irkesome, fearfull, and cold countrey.' On the 13th of June the survivors, twelve in number, left the desolate shore after a stay of ten months. Barentz and two others were so worn out with disease, that they died soon after, amid all the privations of exposure in small boats in an ice-encumbered sea. The remainder struggled onwards, manfully overcoming the perils that beset them; and in September reached the coast of Lapland, where 'wee saw some trees on the river side, which comforted us, and made us glad, as if wee had then come into a new world; for in all the time that wee had been out we had not seene any trees.' On the 11th of the same month, after a voyage of 1143 miles, these brave-hearted men set up their boats in the 'merchants' house at Coola, as a sign and token of their deliverance;' and embarking on board a Dutch ship, in the course of a few weeks once more set foot in their native country.

Henry Hudson, 'the North Seas' great Columbus,' comes next in the list of explorers. In his first voyage, with a crew of only ten men and a boy (1607), he penetrated as far as 82° of north latitude, and discovered part of the eastern coast of Greenland. His second attempt was made on the track of Barentz, but with no better success. In his third and last voyage in 1610, he passed the strait which now bears his name, and entered the great inland sea known as Hudson's Bay. Concluding that this led to the north-west passage, he passed the winter there, with the intention of resuming operations early in the following year; but in the spring his crew, wearied with hardship, mutinied, and Hudson, with his son and seven others, was turned adrift in a small boat, and never afterwards heard of:

> 'Of all the sea-shapes death has worn, may mariners never know
> Such fate as Hendrik Hudson found in the labyrinths of snow.'

We are told in the history of the voyage, that later in the same day on which the fated few were abandoned, the conspirators saw the boat again, when 'they let fall the main-sayle, and out with their top-sayles, and flye as from an enemy.' Continuing thus that night and the next day, 'they saw not the shallop, nor ever after.' But punishment overtook the perpetrators of this foul crime: four were killed in a skirmish with the Esquimaux near Cape Digges; and another died on the passage to Ireland, where the survivors arrived in a famishing condition, having been reduced to such extremities for want of food as to devour their candles. Strange to relate, no attempt was made to bring the mutineers to trial; some of them, indeed, were afterwards employed in further explorations.

Great hopes were entertained that the much-desired passage would be found leading out of Hudson's Bay; and a good deal of controversy on the question arose from time to time among contending voyagers and their abettors. Old Purchas says, 'As the world is much beholding to that famous Columbus, for that hee first discovered unto us the West Indies; and to the Portugal for the finding out the ordinarie and as yet the best way that is knowne to the East Indies by Cape Bona Speranza; so may they and all the world be in this beholding to us in opening a new and large passage, both much neerer, safer, and farre more wholesome and temperate through the continent of Virginia, and by Fretum Hudson, to all those rich countries bordering upon the South Sea in the East and West Indies.'

Between this period and 1616, those arms of the sea known as Sir Thomas Rowe's Welcome and Fox Channel were discovered; and in the year just mentioned Baffin sailed into and explored the vast bay, 800 miles long, and 300 wide, named after him. For a long time his report of its great length was disbelieved, but later researches have confirmed the accuracy of his statements; even the latitudes laid down by him are almost identical with those recently determined with all the advantage of superior instruments. Among other openings, Baffin saw Lancaster Sound, and had he explored it, Parry's discoveries would have been anticipated by two hundred years, as they had been to some extent by the long-forgotten Northmen. The opinion, however, at that time, and indeed until within the past thirty years was, that no practicable opening to the Polar Sea existed except that at Behring's Strait. From this period to about the middle of last century, the outlets to the west of Hudson's Bay were the points to which effort was directed; and truly may it be said that these earlier navigators left very little for those who came later. In small vessels, varying from ten to fifty tons burthen, they accomplished more than has since been effected by lavishly-equipped expeditions.

In 1743 parliament offered a reward of £20,000 to any one who should sail to the north-west by way of Hudson's Strait, which passage, it was declared, would be 'of great benefit and advantage to the kingdom.' Between 1769–72 Mr Hearne undertook three overland journeys across the territories of the Hudson's Bay Company to the shores of the Polar Sea. He failed in the first two attempts; in the third he succeeded in reaching a large and rapid river—the Coppermine—and followed it down nearly to its mouth, but, as there is reason to believe, without actually viewing the sea. The proof of the existence of the river was the most important result of Mr Hearne's labours; for such scientific observations as he attempted are loose and unsatisfactory.

In the following year (1773), in consequence of communications made to the Royal Society on the possibility of reaching the North Pole, Captain Phipps was sent out with two vessels to effect this interesting object. He coasted the eastern shore of Spitzbergen to 80° 48′ of latitude, and was there stopped by the ice, and compelled to return. In 1776 Cook sailed on the fatal expedition which cost England her famous navigator, with instructions to attempt the passage of the Icy Sea from Behring's Strait to Baffin's Bay. The clause of the act above referred to, wherein Hudson's Strait was exclusively specified, was altered to include 'any northern passage' for ships; and £5000 was further voted to any one who should get within one degree of the pole. Cook, with all his perseverance, could not penetrate beyond Icy Cape, latitude 70° 45′, where he found the ice stretching in a compact mass across to the opposite continent, which he also visited, sailing as far as Cape North on the coast of Asia. It would appear that expectations prevailed of the enterprising mariner's success, for a vessel was sent to Baffin's Bay to wait for him, in 1777, in charge of Lieutenant Pickersgill. One other journey within this century remains to be noticed—that by Mackenzie, under sanction of the Hudson's Bay Company, with objects similar to those of Hearne. In 1789 he left Fort Chipewyan, crossed Slave Lake, and descended the Mackenzie River, a stream of much greater magnitude than the Coppermine, to an island where the tide rose and fell. But, as in the case of his predecessor, we have no certainty that he reached the ocean. Rivers, however, play an important part in Arctic discovery; and it was something gained to know that the sea could be reached by their means. We may here observe once for all that these land expeditions, whose prime object has been to determine the northern coast-line of America, are not to be confounded with the attempts to discover the north-west passage.

The result of these discouragements was a cessation of naval researches, which continued for many years; but at length a change took place, as sudden and inexplicable as the accumulation of ice from centuries before which cut off the Danish colonies in Greenland from communication with the mother country. In 1816–17 the Greenland whalers reported the sea to be clearer of ice than at any former time within their knowledge. This fact engaged the attention of the Admiralty; and the Council of the Royal Society were consulted as to the prospects of renewed operations in the Arctic regions. Their reply was favourable; and in 1818 two expeditions were fitted out—the one to discover the north-west passage, the other to reach the pole. Captain (now Sir John) Ross and Lieutenant (now Sir Edward) Parry, in the vessels *Isabella* and *Alexander*, were intrusted with the former of these objects.

They were especially charged to examine the great openings described by Baffin as existing at the head of the vast bay which he so diligently explored; and in carrying out these instructions, the commanders found full reason to applaud the care and perseverance of the able navigator who had preceded them by two hundred years. It must be remembered that we are now treating of a period when science put forward its imperative claims, and when, as at present, something more was required than a meagre chart of a previously-unexplored coast, and graphic accounts of new countries and their inhabitants. Astronomy, geology, meteorology, magnetism, natural history, were all clamorous for new facts, or for satisfactory tests of those already known. For the same reason it is that of late years exploring expeditions have been more interesting to the philosopher than to the general public. Lord Anson returning from the southern seas with wagon-loads of Spanish dollars and doubloons would be hailed with popular acclaim; while Sir James Ross arriving from the Antarctic Ocean with materials for accurate magnetic charts, and records of soundings deep as Mont Blanc's altitude, is the hero of the scientific world.

The open state of the sea greatly facilitated the purposes of the expedition. In August the ships were sailing up Lancaster Sound, with every prospect of an easy passage to the westward; when the commander, fancying that he saw a range of mountains barring all further progress in the distance, hesitated to advance, and finally, throwing away the favourable opportunity, returned with his consort to England.

The *Dorothea* and *Trent*, commanded by Captain Buchan and Lieutenant (now Sir John) Franklin, comprised the expedition destined for the pole. Captain Beechey, to whom we are indebted for an interesting account of the voyage, observes—'The peculiarity of the proposed route afforded opportunities of making some useful experiments on the elliptical figure of the earth; on magnetic phenomena; on the refraction of the atmosphere in high latitudes in ordinary circumstances, and over extensive masses of ice; and on the temperature and specific gravity of the sea at the surface, and at various depths; and on meteorological and other interesting phenomena.' The vessels sailed in April 1818, Magdalena Bay in Spitzbergen having been appointed as a rendezvous in case of separation. For a time they made good progress to the northward, keeping near the shore. At length a furious gale came on, with all the snowy, sleety bitterness of the north, freezing upon the rigging, and encumbering alike the movements of vessel and crew. The *Dorothea* was only saved from being driven on shore by forcing her into the main pack of ice, which afforded shelter. The *Trent*, although in less peril, had suffered severely in the storm; and reluctantly the grand object—pushing northwards—was given up as hopeless. Lieutenants Franklin and Beechey proposed to renew the attempt with dogs, sledges, and baidars—the skin-boats of the Esquimaux—appliances which experience has shown to be generally the most serviceable in ice travelling; but for that time nothing came of the project.

The phenomena peculiar to the north were new to most of those embarked on this expedition. The novelty of constant daylight for several weeks prevented some of the party from taking needful rest, until necessity compelled them to obey the natural laws, as observed by other animated creatures in those regions. Captain Beechey writes—

'Very few of us had ever seen the sun at midnight; and this night happening to be particularly clear, his broad red disk, curiously distorted by refraction, and sweeping majestically along the northern horison, was an object of imposing grandeur, which rivetted to the deck some of our crew who would perhaps have beheld with indifference the less imposing effect of the icebergs. The rays were too oblique to illumine more than the inequalities of the floes, and falling thus partially on the grotesque shapes either really assumed by the ice, or distorted by the unequal refraction of the atmosphere, so betrayed the imagination, that it required no great exertion of fancy to trace, in various directions, architectural edifices, grottos, and caves here and there, glittering as if with precious metals.'

Among other topics Captain Beechey enters on the theory of iceberg formation, and contrasts it with the analogous effects in an Alpine glacier. The latter slopes, while the former always presents a perpendicular face to the sea—a result produced by the continual increment of rain and snow, and the action of sea-water below in preventing expansion of the base. Icebergs, in fact, are amongst the most surprising of Arctic phenomena. On one occasion the discharge of a musket half a mile distant caused a huge mass to fall, the wave from which heaved a boat with its crew ninety-six feet up the beach, and there left it stove in. Shortly afterwards, the two lieutenants were viewing another part of the same berg, when an avalanche of ice slid from it with a plunge that disturbed the ship four miles away; although they themselves, by keeping the boat's head to the swell, rode it over in safety. On this Captain Beechey remarks—'The piece that had been disengaged at first wholly disappeared under water, and nothing was seen but a violent boiling of the sea, and a shooting up of clouds of spray, like that which occurs at the foot of a great cataract. After a short time it reappeared, raising its head full a hundred feet above the surface, with water pouring down from all parts of it; and then, labouring as if doubtful which way it should fall, it rolled over, and after rocking about some minutes, at length became settled. We now approached it, and found it nearly a quarter of a mile in circumference, and sixty feet out of the water. Knowing its specific gravity, and making a fair allowance for its inequalities, we computed its weight at 421,660 tons. A stream of salt water was still pouring down its sides, and there was a continual cracking noise, as loud as that of a cart-whip, occasioned, I suppose, by the escape of fixed air.'

The failure in the chief object of these two expeditions excited feelings which could only be satisfied by renewed exertions. The mountains said to exist at the bottom of Lancaster Sound were affirmed, by some who had borne part in the abortive voyage, to be ocular deception. The question was soon put to the proof. Two ships, the *Hecla* and *Griper*, commanded by Captain Parry, sailed to explore Lancaster Sound on the 4th May 1819. Every effort was made to arrive on the scene of operation at the earliest possible period, and as the shortest route, the ships were forced into the 'Middle Ice' in Baffin's Bay in the middle of July. This collection of ice is as striking a phenomenon in this part of the sea, as are the great banks of weed, *Fucus natans*, which float with little or no change of place in the Atlantic, off the Azores and the Bahamas. As its name indicates, it occupies a position in the middle of the bay, leaving a narrow channel on the eastern side, more or less encumbered with drift ice, while on the western side the sea is generally unobstructed. The local position of this body of ice is supposed to be due to the action of conflicting currents, which retain it pretty nearly in one spot. The usual route round its northern extremity, followed by whaling ships, doubles the length of a voyage, and whenever possible, they endeavour to cross the pack in a lower latitude. This was what Parry did. By dint of sawing, heaving, and sailing at the rate of about twelve miles a day, he forced his way through the barrier, more than eighty miles in width, in seven days. A clear sea awaited him on the western side; and by the end of July he was in the entrance of Lancaster Sound, waiting with anxiety and impatience for an easterly breeze. It came at last; both vessels crowded sail; and as Captain Parry relates—'It is more easy to imagine than to describe the almost breathless anxiety which was now visible in every countenance while, as the breeze increased to a fresh gale, we ran quickly up the Sound. The mast-heads were crowded by the officers and men during the whole afternoon; and an unconcerned observer, if any could have been unconcerned on such an occasion, would have been amused by the eagerness with which the various reports from the crow's nest were received—all, however, hitherto, favourable to our most sanguine hopes.' The question as to a passage was soon settled. 'We were,' pursues the narrative, 'by midnight in a great measure relieved from our anxiety respecting the supposed continuity of land at the bottom of this magnificent inlet, having reached the longitude of 83° 12′, where the two shores are still above thirteen leagues apart, without the slightest appearance of any land to the westward of us for four or five points of the compass.'

An inlet ten leagues wide, on the southern shore, was next seen. Thinking that this would lead to the American continent, Captain Parry sailed into it for some distance until stopped by the ice. While here, the singular phenomenon was observed, as it had been by former voyagers, of the compasses becoming useless, the needles losing all directive power, and pointing to any direction in which they might be turned. This effect, which added materially to the difficulty of navigating an unknown sea, was due chiefly to the proximity of the magnetic pole: a successful means of correcting it has since then been discovered, as will be hereafter explained. From this channel, to which the name of Regent's Inlet was given, the ships returned to Barrow's Strait, where, on the 22d August, another wide opening of eight leagues was discovered on the northern shore. Far as the eye could reach it was clear of ice, but no attempt was made to explore it, as all on board the vessels were desirous of getting to the westward: it was called Wellington Channel. Beyond this several islands were passed, the whole group now known as the Parry Islands; and during this part of the voyage a change was noticed in the general direction of the compass needle from westerly to easterly, showing, as Captain Parry observes, that they had 'crossed immediately to the northward of the magnetic pole, and had undoubtedly passed over one of those spots on the globe where the needle would have been found to vary 180°, or, in other words, where its north pole would have pointed due south.'

Sailing onwards, the passage narrowed; Melville Island was discovered and named; and on the 4th September the party became entitled to the parliamentary reward of £5000 offered for attaining 110° of west longitude; a gratifying fact duly commemorated in the appellation of an adjacent headland — Bounty Cape. The narrowing of the channel disappointed the explorers in their hope of making their way to Behring's Strait in one season. Ice was met with; on the 14th September a sudden fall of snow indicated the close of the fine season; the *Griper* was forced on shore; and though got off again, the obstructions were such as to make it evident that no time was to be lost in looking for winter quarters. With some difficulty the course was retraced to a bay in Melville Island; but new ice seven inches in thickness formed so rapidly, that before the vessels could be brought to their anchoring-ground, a channel more than two miles long had to be cut to admit them.

All heavy materials and stores were immediately landed, the decks cleared, and each vessel housed over with a thick tilt-cloth; and to insure as much snugness as possible under the circumstances, the sides were banked up with snow. Notwithstanding the heating apparatus distributed throughout each ship, the sleeping berths were nearly always damp, and coated with ice; and whenever the external air was admitted by the opening of a door, the sudden rush of cold condensed the warm air of the apartment to a visible vapour, which settled and froze on the bulk-heads and beams. Later in the season the berths were taken down, and hammocks slung a-midship substituted for them, very much to the comfort and health of the crews—an arrangement which has been followed in subsequent voyages with equal benefit. During the winter all available means were taken to promote health and cheerfulness: when the weather permitted, the men took exercise on shore, and on other occasions were made to run round the deck to the tunes of a hand-organ or to their own songs. Dramatic entertainments were prepared: the first representation took place on the day on which the ice-bound adventurers lost sight of the sun, to see it no more for three dreary months, and was repeated fortnightly afterwards. A school was opened, and well attended by the crews, who found learning to read a valuable relief from *ennui* and its concomitant evils; and the officers, among other modes of using the time, started a weekly manuscript newspaper — 'The North Georgia Gazette and Winter Chronicle'—in which humour and philosophy were mingled, to the amusement and edification of writers and readers. Those who understand the intimate connection between mental and physical health will best appreciate these attempts to provide occupation for mind and body. But the scientific objects of the expedition were not forgotten: in the observatory built on shore astronomical, magnetical, and meteorological observations were perseveringly recorded, in spite of the rigorous climate, and when the cold was such that to touch the metal of the instruments raised a blister, or took off the skin, just as in a case of burning, it was necessary to hold the breath while observing, otherwise a thin film of ice formed on the eye-glasses. Several phenomena peculiar to northern latitudes were taken account of: curious effects of refraction, appearances of the aurora, facility of hearing sounds at great distances—in calm weather conversation could be held between two individuals more than a mile apart with but a slight elevation of the voice; smoke did not rise, but crept along for several miles in a horizontal direction; objects seen at a distance in the dreary waste of snow deceived the eye, and appeared much larger than they were in reality. February 1820 was the coldest part of the season; the temperature fell to 55° below zero, a degree of frigor which might well be supposed to be unbearable; yet if there be no wind, it can be borne without pain. Mercury froze so as to become malleable, and could be beaten into a variety of forms.

In March preparations were made to fit the ships again for service; the ice which had accumulated inside the *Hecla* from breath and steam was scraped off, making a quantity of seventy-five bushels. On the 12th and 13th May the first ptarmigan, deer, and musk ox, were seen; the animals pass every spring from the mainland to the islands to graze and breed. On the 1st June a party set out to cross the island to its northern shore: the pools were full of fowl, the rapid fervour of an Arctic summer had already converted the snowy waste into 'luxuriant pasture ground,' rich in flowers and grass, with 'almost the same lively appearance as that of an English meadow,' a fact which fully accounts for the periodical migration of animals from the continent.

It was not until the 1st August that the ships were once more fairly afloat, and endeavours made to push to the westward; but the icy barrier which the party had seen on their first approach still barred their progress. The *Griper* again took the ground during a perilous interval, and all further progress in the much-desired direction became hopeless. The heads of the vessels were reluctantly turned to the eastward; they stood out of the sound, surveyed part of Baffin's Bay, and in November returned to England, with all hands, comprising ninety-four individuals, in health, having lost but one during their eighteen months' absence.

In September of the same year that Parry sailed, an overland expedition started from York Factory, Hudson's Bay, under charge of Sir John Franklin, accompanied by Dr (now Sir John) Richardson, two midshipmen —Messrs Back and Hood—and Hepburn a seaman, with the object of exploring the north coast of America to its eastern extremity from the mouth of the Coppermine. There was a chance that Parry might make for the coast in his ships; and if so, the two parties would have co-operated with mutual advantage. Franklin and his party, increased by the addition of sixteen Canadian voyageurs, interpreters, &c. left Fort Chipewyan in July 1820 for Fort Enterprise on Winter Lake, more than 500 miles distant. Here, after walking eighty miles to get a look at the Coppermine, they wintered, while Mr (now Sir George) Back returned on foot to Fort Chipewyan to expedite the transit of stores required for the next year's operations. At the end of five months he rejoined his companions, having walked 1100 miles on snow shoes in the depth of winter: a journey which put his powers of endurance to a severe test, the thermometer being seldom above zero, and on one occasion 57° below it. On the last day of June 1821, the whole party having dragged their canoes and baggage to the river—a tedious and fatiguing service—embarked on the rapid stream, and reached the sea on the 18th July. The main object of the expedition then commenced; and with two birch-bark canoes, each manned by ten men, and fifteen days' provision, Franklin paddled to the eastward. They followed the coast for two weeks, pinched at times for want of food, as some of their pemmican had turned mouldy, till they came to what is now called Coronation Gulf, a distance, reckoning the indentations of the shore, of

555 geographical miles. By this time the canoes, which had gone through some rough duty, were scarcely serviceable; and the stock of provisions was reduced to three days' consumption. Under these circumstances the leaders resolved to return. They walked first to a spot on the shore ten miles distant from their haltingplace, which, with literal truth, was named Point Turnagain. To attempt to reach the Coppermine so late in the season would have been fatal to the whole of the party; they therefore made for Hood's River, discovered by them a few days previously, up which they had ascended to the first rapid by the 26th August. Two small portable canoes were then constructed from the two larger ones, for the purpose of crossing rivers on the journey now before them; and on the 1st September they set off on a straight course for Fort Enterprise, 150 miles distant. The fatigues and privations endured on this route are scarcely to be paralleled: short of food, ill supplied with clothing, and exposed to the howling severity of the climate, the escape of any one of the number appears almost a miracle. Some days, when there was nothing to eat, and no means of making a fire, they passed entirely in bed; on others, after a weary and exhausting travel, their only nourishment on halting for the night was *tripe de roche*, or rock-tripe, a species of lichen, *Gyrophora proboscidea* of botanists, a plant of most nauseous taste, and the cause of cruel bowel complaints to the whole party. Daily they became weaker, and less capable of exertion: one of the canoes was so much broken by a fall, that it was burned to cook a supper; the resource of fishing too was denied them, for some of the men, in the recklessness of misery, threw away the nets. Rivers were to be crossed by wading, or in the canoe; on one of these occasions Franklin took his seat with two of the voyageurs in their frail bark, when they were driven by the force of the stream and the wind to the verge of a frightful rapid, in which the canoe upset, and but for a rock on which they found footing, they would there have perished. On the 19th, 'previous to setting out, the whole party ate the remains of their old shoes, and whatever scraps of leather they had, to strengthen their stomachs for the fatigue of the day's journey. These,' adds Franklin, 'would have satisfied us in ordinary times, but we were now almost exhausted by slender fare and travel, and our appetites had become ravenous. We looked, however, with humble confidence to the great Author and Giver of all good for a continuance of the support which had hitherto been always supplied to us at our greatest need.' A day or two afterwards the remaining canoe was left behind; no intreaties could prevail on the men to carry it farther. Dr Richardson, too, was obliged to abandon his collection of plants and minerals from inability to endure the burthen. The killing of five small deer at this time, however, enabled them to rest for a couple of days to recruit their exhausted strength. On the 26th they came to the Coppermine, the crossing of which, owing to their weak condition, the loss of the canoe, and having to construct a raft of willow branches, detained them until the 4th October. They were now almost in the last stage of starvation; and had it not been for the exertions of Hepburn in collecting tripe de roche, not one of them would have survived. On the 7th, when at twenty-four miles from Fort Enterprise, a division of the party took place: Franklin, with eight of the men, went on, while Richardson stayed behind at the encampment to tend on Hood, who was scarcely able to move. Hep-

burn remained with them. Three of the voyageurs, unable to proceed with Franklin, and Michel, an Iroquois, were permitted to return to the haltingplace, where they would be at least certain of fire and rock-tripe, but, with the exception of the Indian, they perished by the way: not one of them was ever seen again. Franklin, with his five survivors, reached Fort Enterprise on the 11th. What a disappointment awaited them! Instead of a cordial welcome from friendly hunters, and abundance of provisions, as had been promised, all was a blank: the building was tenantless.

A note was found from Mr Back, who had journeyed on in advance, stating that he had gone in search of the Indians, and if need were, to Fort Providence. This was but poor comfort for the famished travellers, who were obliged to take up their quarters in the dilapidated edifice. The rubbish-heaps concealed beneath the snow were searched for old skins, bones, or any kind of offal that might serve as food when stewed with rock-tripe. A good fire was a luxury seldom enjoyed, for they had scarcely strength to collect wood. Eighteen weary days were passed in these painful privations, when the monotony was interrupted by the arrival of Dr Richardson and Hepburn in a most emaciated condition, bringing the melancholy intelligence that Mr Hood and the Iroquois were both dead. Michel, in a fit of sullen spite, to which uncivilised natures are liable, had shot the young and talented officer at the encampment where they had last parted; and his demeanour towards the two survivors becoming more and more threatening, the doctor, under the imperious instinct of self-preservation, took upon himself the responsibility of putting the Indian to death by a pistol-shot. As afterwards appeared, there was reason to believe that two of the missing voyageurs had also been murdered by the Iroquois.

Two others of the wretched party died on the second day after Richardson's arrival at the fort. At last, on the 7th November, relief came, borne by three Indians sent by Mr Back. The messengers proved themselves most kind, assiduous attendants, 'evincing humanity that would have done honour to the most civilised people.' And with good fires and sufficient food, the sufferers began to recover strength. A week later, they were able to set out for Fort Chipewyan, where they remained until June of the following year. In July they reached York Factory, from whence they had started three years before, and thus terminated a journey of 5550 miles, during which human courage and patience were exposed to trials such as few can bear with fortitude, unless, as is seen in Franklin's interesting narrative, arising out of reliance on the ever-sustaining care of an Almighty Providence.

The possibility of entering the Polar Sea having been proved by Parry's first voyage, it was considered that the north-west passage might probably be effected in a lower latitude than that of Melville Island, where the icy barrier had proved impassable. Parry, accordingly, was sent out a second time with the *Hecla* and *Fury*, in May 1821, with instructions to make for Repulse Bay by way of Hudson's Strait. The former never having been fully examined, it was supposed that some opening would be found leading from it to the ocean beyond. Hudson's Strait is notorious for its manifold hindrances to navigation, and the 2d August had come before the ships reached the narrow channel between Southampton Island and the mainland, named Frozen Strait by Middleton, who was baffled by it in 1742. At the end of August the vessels were in Repulse Bay, which, owing to some physical cause not easy of explanation, but which not unfrequently operates in the Arctic Seas, was almost clear of ice. Boat parties were immediately set to explore the shores, and the result of their labours proved the entire continuity of land round the bay, and consequently the non-existence of any passage to the western waters. Every opening in the coast towards the south-east was then diligently examined, in which service the ships were beset by floating ice, and in a few days drifted back the whole distance gained by a month's hazardous sailing. The season for exploration was now over; a secure anchorage was found off Winter Island, where the winter was passed similarly to that described in the former voyage, but with less tedium; for a party of sixty Esquimaux — men, women, and children, with dogs and sledges—took up their residence on the island early in 1822, and afforded continual interest to the voyagers in studying their habits, manners, resources, and their adaptation to surrounding nature. Even under such apparently uncongenial circumstances human ingenuity manifests itself: these people build their winter huts dome-shaped, with blocks of snow, as accurately as though they had studied the geometrical principles of such constructions. They display great skill also in fitting and sewing their dresses, and in the manufacture of canoes, weapons, and domestic implements. They eat little else than animal food, and whenever they can get it, will devour from ten to twelve pounds of flesh or blubber in a day. Their only domestic animal is the dog: deprived of this useful creature, their existence would be extremely precarious. On the long journeys which they take in search of food, six of these dogs will draw a sledge with a load of half a ton from seven to eight miles an hour during a whole day.

On the 2d July the ships were released from their frozen berths, and attempts made to sail to the northwards by Fox's Channel—a most harassing tideway, where more than once both ships were nearly destroyed by pressure from floating ice: so formidable were the obstacles, that sixty-five days were spent in making forty miles! The elements proved unpropitious, and at the end of October the vessels were once more in winter quarters at the Island of Igloolik; thirteen days' work having been necessary to cut a canal 4343 feet long through ice from twelve to fourteen inches, and in some places several feet, in thickness. Here the Esquimaux were more numerous than at Winter Island.

Not until August 8, 1823, could the ships be extricated from this new station; and no sooner were they freed, than they were again beset by drifting ice, which held them for twenty-four days. The risk of passing another winter in those dreary regions appeared to be imminent, when an easterly breeze sprung up, and carried the vessels into open water. They arrived at Shetland in October, after nearly three years' absence, and the eyes of all on board were gladdened once more with the sight of civilised humanity. The north-eastern point of the American continent was ascertained by this voyage: it is a projecting headland of Melville Peninsula, and the connection of the latter with the main was found to be by a tortuous and narrow isthmus; and with respect to a navigable passage to the Polar Sea, it proved that the only route to the westward lay through Barrow's Strait or Regent's Inlet.

A third expedition, including the same ships with the same commander, was sent out in 1824. Owing to the unfavourable nature of the middle ice in Baffin's Bay, the season was so far advanced by the time the party entered Regent's Inlet, that they at once went into winter quarters at Port Bowen, on its eastern shore. Here they remained until the 20th July 1825, when the voyage was resumed, but under very discouraging circumstances. Great accumulations of ice rendered it almost impossible to advance; the *Fury* was driven on shore, and abandoned, though most of her stores were saved, and piled on the beach; and the *Hecla* returned to England with a double complement of men and officers. This was the least successful of Parry's voyages; but there is a fact connected with it which deserves to be recorded: it proved that the anxiety and difficulty consequent on the loss of power in the compasses need no longer exist. The placing of a small circular plate of iron in the line of no direction of the ship, and near to the needle, effects a compensation which keeps the latter in working condition. This contrivance is due to Mr Peter Barlow of Woolwich, and Captain Parry says, 'Never had an invention a more complete and satisfactory triumph; for to the last moment of our operations at sea did the compass indicate the true magnetic direction.'

Concurrently with Parry's third voyage three other expeditions were undertaken: the first by Captain Lyon, in the *Griper*, to proceed by Hudson's Strait and Sir Thomas Rowe's Welcome to Repulse Bay; then to cross over Melville Isthmus, and survey the coast of America as far as where Franklin left off at Point Turnagain. The vessel sailed in June 1824, but being totally unfit for the service, except in the quality of strength, she was nearly wrecked on two occasions in the Welcome, and all on board placed in imminent peril of their lives; and at last, Repulse Bay being eighty miles distant, the enterprise was abandoned.

These expeditions had the twofold object of making the north-west passage and of completing the survey of the North-American coast. Captain Beechey was appointed to command the second, and despatched in the *Blossom*, in 1825, on a similar errand to that now intrusted to Captain Collinson with the *Enterprise* and *Investigator;* namely, to sail round Cape Horn, and enter the Polar Sea by Behring's Strait, so as to arrive at Chamisso Island, in Kotzebue Sound, by the 10th July 1826, there to wait for Franklin, of whom more presently. Beechey reached the rendezvous fifteen days after the time appointed, and made immediate preparations for exploring the coast to the eastward. The barge, under charge of two of the lieutenants, surveyed 126 miles of new shore, until stopped by a long, low, projecting tongue of land, to which the name of Point Barrow was given, but without meeting or hearing any tidings of the expected overland party. The *Blossom* remained at the anchorage until October, when it became necessary to depart, to prevent her being frozen in for the winter, and after a cruise in the Pacific, she returned to Chamisso Island in August 1827. Climate, however, with its usual fickleness, was unfavourable; there was very little open sea; and in endeavouring to push along the shore, the barge was wrecked, and several of her crew drowned; and on the 6th October Captain Beechey was obliged to abandon further exploration, grieved and disappointed that he had not the satisfaction of bearing with him the adventurous party whom he had been sent especially to meet.

This party comprised the third of the expeditions referred to above. In 1824, Franklin, undeterred by the recollection of the fearful hardships endured in his former overland journey, proposed a second, which, descending the Mackenzie River to the sea, should there divide its force; and while one party explored the coast easterly to the Coppermine, the other should make its way westerly to Icy Cape, or, if possible, Behring's Strait. The project was duly sanctioned, and every preparation made to insure success by building boats, providing scientific instruments, and supplying abundant provisions. Besides three strong and light boats built at Woolwich, better suited to navigation among ice than bark canoes, a smaller one, covered with Mackintosh, and weighing only eighty-five pounds, was constructed for the purpose of crossing rivers. In July 1825 the party arrived at Fort Chipewyan, when a combined plan of operations was determined on, in which Richardson and Back, who had again volunteered, held a prominent place. To the latter, and to Mr Dease, one of the Hudson's Bay Company's traders, was intrusted the preparation of winter quarters, so as to avoid all risk of once more encountering the privations they had before so painfully experienced.

In June 1826 they descended the river, and separated on approaching the sea—Richardson and Kendal going with two boats to the east, and Franklin and Back with two boats to the west, in which direction they hoped eventually to effect a junction with Beechey and the *Blossom.* On the 4th July Franklin's division was attacked by some hundreds of Esquimaux, and only saved by the coolness and judgment of the leaders. Pursuing their voyage, the usual fate of arctic voyagers awaited them—storms, fogs, cold, and ice. The greatest retardation was from the extreme density of the fogs, caused by the low and swampy nature of the coast, into which the most northerly range of the Rocky Mountains sinks. The season was advancing; and after anxious deliberation as to pushing on or returning, the latter course was decided on. The spot was named Return Reef; and on the 18th August the party turned their backs on it, little thinking that Captain Beechey had done so much towards meeting them. On this event Franklin observes:—'Could I have known, or by possibility imagined, that a party from the *Blossom* had been at the distance of only 160 miles from me, no difficulties, dangers, or discouraging circumstances should have prevailed on me to return; but taking into account the uncertainty of all voyages in a sea obstructed by ice, I had no right to expect that the *Blossom* had advanced beyond Kotzebue Inlet, or that any party from her had doubled Icy Cape.' The extent of coast surveyed was 374 miles, the whole of the tamest and most dreary character. The boats got back to Fort Franklin the 21st September, after a voyage of 2048 miles; and there the unsuccessful party met their comrades who had gone eastwards. These had been favoured with fine weather, and their sail of 500 miles, or 902 by the coast line, from one river to the other, afforded a pleasant voyage, during which they added somewhat to the stores of natural history, botany, geology, &c.

A second winter passed at the fort. The cold was intense, at one time the thermometer standing at 58° below zero; but such a temperature even as this may be defied with a weather-tight dwelling, plenty of provisions, and congenial companions. A series of magnetic observations was commenced; and as the locality lay on the opposite side of the magnetic pole to that along which Parry had sailed in his voyages, some interesting results were arrived at. 'It appears,' says Franklin, 'that for the same months, at the interval of only one year, Captain Parry and myself were making hourly observations on two needles, the north ends of which pointed almost directly towards each other, though our actual distance did not exceed 855 geographical miles; and while the needle of Port Bowen was increasing its westerly direction, ours was increasing its easterly, and the contrary—the variation being west at Port Bowen, and east at Fort Franklin—a beautiful and satisfactory proof of the solar influence on the daily variation.'

In addition to magnetism, observations of the aurora borealis were also recorded, and the fact established that no disturbance of the needle (in that locality at least) takes place during the play of the phenomenon. A course of lectures too on practical geology was delivered by Richardson—an eminently useful subject in a new district. And as an instance of what a love for science may accomplish when animated by a persevering and self-reliant spirit, we must not omit to mention Mr Drummond, one of the party, who passed the winter alone at the foot of the Rocky Mountains in a small hut erected by himself, where he collected 1500 specimens of plants, and 200 birds and quadrupeds, besides insects. These, though points of minor interest when compared with the grand objects of the expeditions, serve nevertheless to connect the individuals whose names they distinguish, by many links of sympathy and esteem, with unobtrusive thousands who can admire where they cannot imitate.

The plan which had been proposed by Franklin for reaching the North Pole on the failure of Captain Buchan in 1818 was taken up by Sir Edward Parry after returning from his third voyage; and in April 1827 he sailed for Spitzbergen in the *Hecla*, calling by the way at Hammerfest, to take on board a number of reindeer which were to be employed in drawing the two boats built expressly for the service, and fitted with sledge-runners. Arrived at their destination, the vessel was anchored in a harbour on the northern coast, while Parry, with Lieutenants Ross and Bird, Beverly the surgeon, and twenty-four men, started on their novel enterprise. The central point to which their hopes and wishes tended was 600 miles distant; and to quote the commander's words—'It was proposed to take with us resources for ninety days; to set out from Spitzbergen, if possible, about the beginning of June; and to occupy the months of June, July, and August in attempting to reach the pole, and returning to the ship, making an average of 13½ miles per day.' Each boat, with the contents, weighed 3573 lbs., or 268 lbs. to each man. Among the stores was a good supply of that prime essential in Arctic travelling, pemmican, which combines abundant nutriment with small compass. It is made from beef dried over wood fires, and pounded, and preserved in bags, with fat to exclude the air.

On the 13th June the party were off Little Table Island, discovered by Phipps in 1773. It is the most northerly land on the globe at present known, and though but little more than a rock a few hundred feet high, its position is such that, as Parry observes, 'bleak, barren, and rugged as it is, one could not help gazing at it with intense interest.'

In 1806 Captain Scoresby had sailed as high as 81° 30′, and reported the ice then stretching to the northwards as a smooth unbroken level, a description which unfortunately would no longer apply in 1827. Where the water was open, the crews availed themselves of sails and oars; but when they came to the ice, the dragging of the boats proved to be a more formidable task than was anticipated. The reindeer had been left behind at Spitzbergen as useless under the circumstances, since there could be no provender for them, and the labour of moving the heavy loads was fatiguing in the extreme. A level surface was rarely met with: the ice was nearly everywhere ridged with hummocks, furrowed with deep hollows full of loose snow or water, or broken up into sharp laminæ, familiarly termed 'penknife ice' by the sailors.

Although the season of the arctic summer, when there is constant sunlight, the temperature was seldom above the freezing-point. All vicissitudes of weather were to be encountered: one day it rained steadily for twenty-one hours without any of that shelter which the land at times affords. The night was chosen for travelling, the glare from the expanse of snow being less painful to the eyes than when the sun was higher, besides which, the day was the best time for drying wet garments. This arrangement proved rather embarrassing; the men scarcely ever knew night from day, and the officers, even with chronometers, would have been sometimes puzzled to tell the hour, had they not been provided with time-keepers constructed to show twenty-four hours on the dial, with but one revolution of the hour-hand in that period. Had they reached the pole, where the sun's apparent height varies very slightly, they would have been unable to retrace their steps without this provision, and might have gone off on a meridian precisely opposite to the true one.

Their labours thus commenced with the evening:—'Being rigged for travelling,' observes Parry, 'we breakfasted upon warm cocoa and biscuit; and after stowing the things in the boats and on the sledges, so as to secure them as much as possible from wet, we set off on our day's journey, and usually travelled from five to five and a-half hours, then stopped an hour to dine, and again travelled four, five, or even six hours, according to circumstances. After this we halted for the night, as we called it, though it was usually early in the morning, selecting the largest surface of ice we happened to be near for hauling the boats on, in order to avoid the danger of its breaking up by coming in contact with other masses, and also to prevent drift as much as possible. The boats were placed close alongside each other, with their sterns to the wind, the snow or wet cleared out of them, and the sails, supported by the bamboo masts and three paddles, placed over them as awnings, an entrance being left at the bow. Every man then immediately put on dry stockings and fur boots, after which we set about the necessary repairs of boats, sledges, or clothes; and after serving the provisions for the succeeding day, we went to supper. Most of the officers and men then smoked their pipes, which served to dry the boats and awnings very much, and usually raised the temperature of our lodgings 10° or 15°. This part of the twenty-four hours was often a time —and the only one—of real enjoyment to us: the men told their stories, and "fought all their battles o'er again;" and the labours of the day, unsuccessful as they too often were, were forgotten. A regular watch was set during our resting-time, to look out for bears or for the ice breaking up around us, as well as to attend to the drying of the clothes, each man alternately taking this duty for one hour. We then concluded our day with prayers; and having put on our fur dresses, lay down to sleep with a degree of comfort which perhaps few persons would imagine possible under such circumstances; our chief inconvenience being, that we were somewhat pinched for room, and therefore obliged to stow rather closer than was quite agreeable. The temperature, while we slept, was usually from 36° to 45°, according to the state of the external atmosphere; but on one or two occasions it rose as high as 60° to 66°, obliging us to throw off a part of our fur dress. After we had slept seven hours, the man appointed to boil the cocoa roused us, when it was ready, by the sound of a bugle, when we commenced our day in the manner before described.

'Our fuel consisted entirely of spirits of wine, of which two pints formed our daily allowance, the cocoa being cooked in an iron boiler over a shallow iron lamp with seven wicks—a simple apparatus, which answered our purpose remarkably well. We usually found one pint of the spirits of wine sufficient for preparing our breakfast—that is, for heating twenty-eight pints of water, though it always commenced from the temperature of 32°. If the weather was calm and fair, this quantity of fuel brought it to the boiling-point in about an hour and a-quarter; but more generally the wicks began to go out before it had reached 200°. This, however, made a very comfortable meal to persons situated as we were. Such, with very little variation, was our regular routine during the whole of this excursion.'

Arctic land presents no very inviting prospect, but the frozen surface of an arctic sea is drearier still. While Parry and Ross marched on ahead of the boats to beat a track, the most insignificant objects became a source of intense interest and curiosity. One warm day two flies on the ice were regarded with a degree of attention that would have been ludicrous under other circumstances; and equally important was the sight of an *aphis borealis* in a languid state a hundred miles away from land. Such, with the varying nature of the ice, and efforts consequent thereon, and changes of the weather, were the only incidents to relieve the monotony of daily toil. Rain is not frequent in the north, but during this journey it rained more than in the whole of seven previous summers in a lower latitude. All these facts have to be taken into consideration in order to form an accurate idea of the obstacles to be overcome in arctic travel; and it is satisfactory to observe that, notwithstanding these, the promotion of science has not been lost sight of by the explorers. On the 17th July Parry and his officers took hourly observations on all natural phenomena observable by means of the instruments in their possession, in accordance with an arrangement proposed by the Royal Society of Edinburgh for simultaneous hourly observations throughout that day.

The conviction soon forced itself on the minds of the principals, that reaching the pole over such ice as daily impeded them was out of the question. Sometimes they gained no more than fifty yards in two hours; once, after eleven hours of hard work, the advance made was only two miles. The difficulty was further increased by a current setting to the southward, by which they lost more ground than they gained. After a day's severe labour in dragging the boats for twelve miles, they were but five miles nearer to the pole than when they started in the morning; on another occasion they lost thirteen miles in twenty-four hours, the southerly drift running at times five miles an hour. Defeated in their main object, the latitude of 83° became the assigned goal; yet even in this they were disappointed, and after struggling for thirty-five days against multiplied difficulties, they were compelled to give up in latitude 82° 45′, with the sole satisfaction that in all human probability no adventurers had ever before penetrated so far. This was on the 23d July, 172 miles from the ship.

'To accomplish this distance,' writes Parry, 'we had traversed, by our reckoning, 292 miles, of which about 100 were performed by water, previously to our entering the ice. As we travelled by far the greater part of our distance on the ice three, and not unfrequently five times over, we may safely multiply the length of the road by two and a-half; so that our whole distance, on a very moderate calculation, amounted to 580 geographical, or 668 statute miles, being nearly sufficient to have reached the pole in a direct line.' Soundings had been taken more than once during the journey, and depths obtained varying from 200 to 400 fathoms; here, at the ultimate haltingplace, no bottom was found with 500 fathoms of line. The party were again in the open sea on the 11th August, at fifty miles distance from Table Island, after forty-eight days on the ice; and ten days later, they arrived on board the *Hecla*, having been absent nine weeks, and travelled in the whole more than 1100 miles.

Next in chronological order is the expedition equipped at the cost of Sir Felix Booth, and conducted by Captain Ross, and his nephew, Commander (now Sir James) Ross. They sailed in May 1829, in the *Victory*, a vessel fitted with a steam-engine in addition to her sails, so as to be able to navigate in calm weather or in baffling winds. The object of the voyage was to search for the north-west passage, as Parry had done before, by some opening leading out of Regent's Inlet: they arrived in this inlet in August, and took on board a large quantity of the *Fury's* stores, which had been piled on the beach when that vessel was cast away: of the ship herself not a vestige remained. They then sailed for two hundred miles along the east and south-east coast of the land, called North Somerset by Parry, and named Boothia by Ross, in honour of his patron, and wintered in Felix Harbour, from which the *Victory* was not liberated for a whole year. The narrative of this voyage, indeed, affords little more than a continued succession of difficulties and disasters: the steam-engine was thrown overboard as a useless encumbrance; the ship was either firmly beset, or unable to make her way among the ice when at liberty, and was at last abandoned, leaving the party with no resource but the boats and the *Fury's* stores: without the latter they must have been starved to death. Two dreary winters did they pass on the beach where these stores had been piled, in a building to which they gave the name of Somerset House. In April 1833 they began to carry provisions by toilsome journeys, and make deposits at various places along the coast in the direction of their route. Not until the 14th August of this year did the ice open to afford them a path of escape from their miserable imprisonment—miserable, although there was no want of food. Happily they at length made their way to Barrow's Strait, where they were taken up by a whale ship, and brought to England.

One interesting fact brought to light by this voyage affords some relief to its long and barren series of disasters—the discovery of the north magnetic pole; the situation of which on the land of Boothia is marked on the map. It was made by Commander James Ross on one of his exploring excursions. 'The place of the observatory,' he remarks, 'was as near to the magnetic pole as the limited means which I possessed enabled me to determine. The amount of the dip, as indicated by my dipping-needle, was 89° 59′, being thus within one minute of the vertical; while the proximity at least of this pole, if not its actual existence where we stood, was further confirmed by the action, or rather by the total inaction, of the several horizontal needles then in my possession.' This was very nearly the position assigned to it by scientific men several years earlier, and arrived at by protracting the direction lines of compass-needles in various circumjacent latitudes, till they met in a central point. Parry's observations placed it eleven minutes distant only from the site determined by Ross.

'As soon,' says the latter, 'as I had satisfied my own mind on the subject, I made known to the party this gratifying result of all our joint labours; and it was then that, amidst mutual congratulations, we fixed the British flag on the spot, and took possession of the North Magnetic Pole and its adjoining territory in the name of Great Britain and King William IV. We had abundance of materials for building in the fragments of limestone that covered the beach, and we therefore erected a cairn of some magnitude, under which we buried a canister containing a record of the interesting fact, only regretting that we had not the means of constructing a pyramid of more importance, and of strength sufficient to withstand the assaults of time and of the Esquimaux. Had it been a pyramid as large as that of Cheops, I am not quite sure that it would have done more than satisfy our ambition under the feelings of that exciting day. The latitude of this spot is 70° 5′ 17″, and its longitude 96° 46′ 45″ west.'

Even if the pole were stationary, this determination could only be regarded as approximate; but when we know that the centre of magnetic intensity is a movable point, we shall readily understand that the cairn erected with so much enthusiasm can now only show where it *was*. According to Hansteen, the pole moves 11′ 4″ every year, and revolves within the frigid zone in 1890 years, so that it will not reach the same spot in Boothia until the year 3722! The precise determination of this point, however, is said to be comparatively unimportant, because its position can always be ascertained by observations of the compass and dipping-needles.

Ross's protracted stay of four years in the inhospitable north induced the government to send out an expedition to look for the absent party. Back, who was then in Italy, hurried home to volunteer his services: his offer was accepted; and with Dr King, surgeon and naturalist, he left England in February 1833. At the Hudson's Bay Company's post, Norway House, the usual complement of voyageurs and other attendants awaited them; and in high spirits they started for their winter quarters, on the eastern shore of Great Slave Lake. While a dwelling was being erected, the commander took a trip to Lake Aylmer, out of which flows a stream now known as Back's River, down which he hoped to pass the following year to the sea.

In April 1834 news reached them of the return of Ross and his crew to England—a fact which animated them with greater spirit for new discoveries. In June they descended the river—a hazardous feat, as will be conceived from Back's description of the stream on arriving at the sea on the 29th July:—'This, then, may be considered as the mouth of the Thlew-ee-choh, which, after a violent and tortuous course of 530 geographical miles, running through an iron-ribbed country without a single tree on the whole line of its banks, expanding into fine large lakes with clear horisons, most embarrassing to the navigator, and broken into falls, cascades, and rapids, to the number of no less than eighty-three in the whole, pours its waters into the Polar Sea in latitude 67° 11′ north, and longitude 94° 30′ west—that is to say, about thirty-seven miles more south than the mouth of the Coppermine River.'

Foul weather prevented the exploration of the coast to Point Turnagain, as had been intended: the utmost that could be done was to send out a walking party, who, after toiling through swamps for fifteen miles, turned back at a low tongue of land named Point Ogle. Nothing but moss and fern grew on the desolate shores; there was no drift-wood; and so damp was the weather, that for ten days, while encamped on Montreal Island, they could not light a spark of fire, or obtain a warm meal. Under these adverse circumstances, after naming the prominent points and islands of the estuary in which they had found so little to cheer them, and taking possession of the country in the name of William IV., they made their way to Fort Reliance—their winter quarters on Slave Lake—and in the following year returned to England.

This was not the last of Back's labours. In 1836, at the instance of the Geographical Society, he attempted to reach Wager Inlet, Repulse Bay, in the *Terror*, as Captain Lyon had so unsuccessfully endeavoured to do twelve years earlier, and for a similar object—the exploration of the shores of Regent's Inlet and of the American continent. The ship sailed in June; in September she was beset by ice in Fox Channel, near Cape Comfort, and there held in its frozen grasp until the 14th July of the following year. It was as though an animated spirit opposed the progress of the party, and determined to punish their daring. The stout ship was at times heeled over almost on her broadside by toppling ice; at others lifted for weeks together on the top of upheaving masses, or compressed between encroaching floes. Human skill was powerless in circumstances which so formidably tasked human courage and fortitude. These qualities were happily not lacking; and indeed without them, the discomfited band of explorers would never have survived to bring their crippled ship back to England.

In 1836 the Hudson's Bay Company resolved on completing, if possible, the survey of those portions of the northern coast which Franklin and Back had failed to reach. This service was intrusted to Messrs Dease and Simpson, two of their employées, with a party of twelve men, who were instructed to descend the Mackenzie River, and on arriving at the sea, endeavour to follow the coast to the westward, either by land or water, as weather and other circumstances permitted, to the point at which Beechey turned back. They were afterwards to explore to the eastward from Point Turnagain of Franklin; to determine whether Boothia Felix were a peninsula, as Ross supposed, or an island; and then to push on in the same direction to some known point which had been visited by Back. In July 1837 they had reached Return Reef, where Franklin was stopped. Beyond this all was new. Two large rivers were discovered, the Garry and Colville, the latter more than a thousand miles in length. Although in the middle of the dogdays, the ground was frozen so hard at four inches beneath the surface, that they could scarcely drive in their tent-pegs. So keen was the north-easterly wind, that 'the spray froze on the oars and rigging; and out in the bay the ice lay smooth and solid, as in the depth of a sunless winter.' Yet even here a few flowers cheered the eyes of the travellers, and enlivened the stubborn soil. On the 1st August, further progress by water being impracticable—they had gained but four miles on the four previous days—Mr Simpson, with some of the men, continued the journey on foot, while Mr Dease and the others remained in charge of the boats. The walking party, after two or three days' travel, fell in with a number of Esquimaux, from whom they hired an oomiak, or family canoe, in which to pursue the voyage along the lanes of open water occasionally visible close to the beach. On the 4th, after passing the mouth of a large, deep river, 'I saw,' says Mr Simpson, 'with indescribable emotions Point Barrow stretching out to the northward, and enclosing Elson Bay, near the bottom of which we now were.' This, it will be remembered, was the farthest point attained by the *Blossom's* barge in 1826, an exploit commemorated by naming the bay after Lieutenant Elson, one of the officers in command.

The party returned to the winter station on Great Bear Lake, and while there, received instructions to renew their search to the eastward, and were informed of Sir G. Back's expedition, with which they were if possible to communicate. They were descending the Coppermine in June 1838 in pursuance of these instructions, when the stream was swollen by spring floods, and encumbered with floating ice, and, in shooting the numerous rapids, 'had to pull for their lives, to keep out of the suction of the precipices, along whose base the breakers raged and foamed with overwhelming fury. Shortly before noon, we came in sight of Escape Rapid of Franklin; and a glance at the overhanging cliffs told us that there was no alternative but to run down with full cargo. In an instant,' continues Mr Simpson, 'we were in the vortex; and before we were aware, my boat was borne towards an isolated rock, which the boiling surge almost concealed. To clear it on the outside was no longer possible; our only chance of safety was to run between it and the lofty eastern cliff. The word was passed, and every breath was hushed. A stream which dashed down upon us over the brow of the precipice more than 100 feet in height, mingled with the spray that whirled upwards from the rapid, forming a terrific shower-bath. The pass was about eight feet wide, and the error of a single foot on either side would have been instant destruction. As, guided by Sinclair's consummate skill, the boat shot safely through those jaws of death, an involuntary cheer arose. Our next impulse was to turn round to view the fate of our comrades behind. They had profited by the peril we incurred, and kept without the treacherous rock in time.'

They had navigated but a short distance along the coast when they were stopped by ice, and lingered many days at Boathaven in a state of utter hopelessness. The time for returning had arrived ere any real work had been accomplished. At length, on the 20th August, Mr Simpson started with seven men for a ten days' walk to the eastward, on the first of which they passed Point Turnagain, the limit of Franklin's survey in 1821. By the 23d they had toiled onwards to an elevated cape, rising from a sea beset with ice, and the land closing all round to the northwards: further progress seemed to be impossible. 'With bitter disappointment,' writes Mr Simpson, 'I ascended the height, from whence a vast and splendid prospect burst suddenly upon me. The sea, as if transformed by enchantment, rolled its free waves at my feet, and beyond the reach of vision to the eastward. Islands of various shape and size overspread its surface; and the northern land terminated to the eye in a bold and lofty cape, bearing east-north-east, thirty or forty miles distant, while the continental coast trended away south-east. I stood, in fact, on a remarkable headland, at the eastern outlet of an ice-obstructed strait. On the extensive land to the northward I bestowed the name of our most gracious sovereign Queen Victoria. Its eastern visible extremity I called Cape Pelly, in compliment to the governor of the Hudson's Bay Company.' This was one of the rewards which compensate the adventurous explorer for seasons of peril and privation.

In 1839 they were more successful, and, favoured with mild weather and an open sea, they sailed through the narrow strait that separates Victoria Land from the main. On the 13th August they doubled Point Ogle, the farthest point of Back's journey in 1834; an event which terminated the long-pursued inquiry concerning the coast-line of the American continent. The survey was now complete. A day or two later, the party, with flags flying, crossed to Montreal Island in Back's Estuary, where they discovered a deposit of provisions which Captain Back had left there five years previously. The pemmican was unfit for use; but out of several pounds of chocolate, half decayed, the men contrived to pick sufficient to make a kettleful of acceptable drink in honour of the occasion. There were also a tin case and a few fish-hooks, of which, observes Mr Simpson, 'Mr Dease and I took possession, as memorials of our having breakfasted on the identical spot where the tent of our gallant, though less successful, precursor stood that very day five years before.'

They had now obeyed their instructions to the letter; the coast-line was determined, and connected with what was previously known to the eastward. It was time to think of returning, but a desire to ascertain if Boothia Felix might not form part of the continent on the opposite side of the estuary led them onwards. By the 20th August they had sailed far enough to see the farther shore, with its capes, of the Gulf of Boothia, which runs down to within forty miles of Repulse Bay; and they then turned back. On their return, they traced sixty miles of the south coast of Boothia, where at one time they were not more than ninety miles from the site of the magnetic pole as determined by Sir James Ross. A long extent of Victoria Land was also examined; and on the 16th September they once more happily entered the Coppermine, after a boat voyage of more than 1600 miles, the longest ever performed in the Polar Sea.

Hitherto we have been occupied with the explorations on and around Northern America, and we now come to the history of those along the continent of Asia, the northern limit of which extends over a space of 145° of longitude. The discovery and survey of this vast region is due entirely to the Russians; for although other nations have attempted the passage, they penetrated no farther than the Karskoie Sea on the west, and Cape North on the east. The first knowledge of the countries which here bound the polar basin was, as in the case of the other continent, derived from private adventurers, who undertook journeys into those desolate latitudes in hopes of a profitable trade in furs, skins, and ivory. Russian traders, sailing from the White Sea and mouth of the Petchora, voyaged as far as Obi and the Iennissei; their vessels, similar to those of early British navigators, were little better than shallops, and it is impossible not to be struck with the labours of those whose chief resource was indomitable perseverance.

The first endeavours under government authority were made about the year 1600; and trading stations were established at the mouths of most of the larger rivers, with the double view of exploration and of subjecting the natives to Russian authority. The Lena, Iana, Indigirka, Alaseia, and Kolyma, were discovered before 1640, by parties sent under Cossack leaders to collect tribute, who at the same time fell in with the Tchuktches, and heard their reports of islands lying off the coast. The earliest attempt to sail to eastward of the Kolyma was made in 1646, and repeated in the two following years, with several small vessels, all of which were wrecked except one commanded by Deshneff, a government functionary, whose name stands high among the early explorers. His grand object was to get round to the mouth of the Anadyr, on the eastern coast, to trade for sable skins; and the summer of 1648 proving favourable to navigation among the ice, he sailed along the shore and through the strait explored by Behring nearly a century later, and founded a settlement at the place to which he was bound—the Anadyr River. This is the only occasion on which such a voyage has been made; and to Deshneff and his companions belongs the honour of having been the first and sole navigators from the Arctic Sea to the Pacific, and of having proved, at a period much earlier than is commonly supposed, that the American and Asiatic continents are not united.

Other expeditions followed; the Bear Islands were seen; and to obtain accurate particulars concerning them, the government of Siberia sent out two parties in 1711, who crossed the ice to the Likahoff Islands, and saw others yet farther to the north. On their return to the mainland, the leaders were murdered by the crews, who feared the hardships of further explorations. Thus the work went on with varying fortune, the positions mostly ill-defined, as must be the case in the absence of accurate instruments, until 1734, the reign of the Empress Anne, when the Russian Admiralty fitted out three expeditions 'to obtain a correct knowledge of the northern coast of Siberia from the White Sea to Behring's Strait:' 'one, consisting of two vessels, was to sail from Archangel eastward to the mouth of the Obi; another from the Obi to the Iennissei. The third was to sail from the Lena, and consisted of two vessels, one of which was to sail westward to the Iennissei, and the other eastward, past the Kolyma, to Behring's Strait.'

Insurmountable impediments to navigation, recall of commanders, wintering in the rivers, overland journeys to St Petersburg, renewed attempts, scurvy, and shipwreck, comprise the history of these expeditions. One of the mates, in observations on the compass, makes the remark, 'The variation of the needle was so great, and it was so unsteady, that I am inclined to believe the magnet ceases to act in these high latitudes.' This fact is worthy of record, as bearing on phenomena which have subsequently been regarded with much attention. But, on the main question: the Russian

Admiralty refused to receive the reports of impossible navigation; and, in 1739, sent out another expedition under Lieutenant Lapteff, who, by dint of perseverance in four successive voyages, did at last pass to the eastward of the Kolyma; but here fields of ice extending far to the north, barred his further progress.

Next in order come the voyages by Behring. This mariner, a Dane by birth, was first employed in explorations by the Czar Peter. It was in 1741 that he sailed through the strait which has since borne his name, to examine the coast of Kamtchatka, which was then supposed to stretch away to the south, and join Japan. After being forty-four days at sea, he was wrecked on a small island, where he died in great misery, and but a small number of his crew survived to return to the mainland and tell the story of his fate. Schalaroff, a merchant of Yakutsk, was equally unfortunate. In 1760 this adventurer, whose name is venerated throughout Siberia, determined on trying whether the passage could or could not be accomplished. He persevered during three seasons, in defiance of mutiny and hardships innumerable. He, too, was wrecked on the desolate coast seventy miles east of Cape Chelagskoi, and, with all his crew, died of starvation. Three years later, Sergeant Andrejeff conducted a sledge expedition across the ice to the Bear Islands; his reports, which were much exaggerated, led shortly afterwards to the accurate survey of this and the adjacent country. Cook's exploration, which has been before referred to, produced another expedition on the part of the Russians, which sailed from the Kolyma in 1787 under Captain Billings; but the attempts made to navigate either to the east or the west were both defeated. Further efforts were made at intervals during the first quarter of the present century, some of them mainly to search for the northern continent, whose existence, far in the Polar Sea, had so often been the subject of rumour. And last we come to the expeditions commanded by Lieutenant Anjou and Admiral von Wrangell, carried on also by means of dogs and sledges from the year 1820 to 1823; the latter taking the mouth of the Kolyma for his starting-point—the former the river Iana. These undertakings were especially promoted by the Emperor Alexander, and were conducted with all the care and skill warranted by an advanced state of science and philosophy. They failed but in one particular—the discovery of the northern continent. How diligently and perseveringly this was searched for, is best proved by the narrative of perils endured, even to the risk of life, in the arduous enterprise. Three times was the frozen surface of the sea traversed without leading to any definite result; on the fourth journey, in March 1823, Von Wrangell reached the latitude of 70° 51′, longitude 175° 27′ west—105 wersts in a direct line from the mainland. Soundings gave a depth of 22½ fathoms; the ice here was thin and weak. More than once the party had only been saved from breaking through by the speed at which the dogs travelled over it. In the distance a screen of dense blue vapour—a certain indication of open water—was visible, on which the admiral remarks:—

'Notwithstanding this sure token of the impossibility of proceeding much farther, we continued to go due north for about nine wersts, when we arrived at the edge of an immense break in the ice, extending east and west farther than the eye could reach, and which at the narrowest part was more than a hundred and fifty fathoms across. . . . We climbed one of the loftiest ice-hills, when we obtained an extensive view towards the north, and whence we beheld the wide immeasurable ocean spread before our gaze. It was a fearful and magnificent, but to us a melancholy spectacle. Fragments of ice of enormous size floated on the surface of the agitated ocean, and were thrown by the waves with awful violence against the edge of the ice-field on the farther side of the channel before us. The collisions were so tremendous, that large masses were every instant broken away; and it was evident that the portion of ice which still divided the channel from the open ocean would soon be completely destroyed. Had we attempted to have ferried ourselves across upon one of the floating pieces of ice, we should not have found firm footing upon our arrival. Even on our own side, fresh lanes of water were continually forming, and extending in every direction in the field of ice behind us. With a painful feeling of the impossibility of overcoming the obstacles which nature opposed to us, our last hope vanished of discovering the land, which we yet believed to exist. We saw ourselves compelled to renounce the object for which we had striven through three years of hardships, toil, and danger. We had done what duty and honour demanded: further attempts would have been absolutely hopeless, and I decided to return.'

On returning from this extreme limit of their adventurous journey, the party were placed in a situation of extreme risk. 'We had hardly proceeded one werst,' writes M. von Wrangell, 'when we found ourselves in a fresh labyrinth of lanes of water, which hemmed us in on every side. As all the floating pieces around us were smaller than the one on which we stood, which was seventy-five fathoms across, and as we saw many certain indications of an approaching storm, I thought it better to remain on the larger mass, which offered us somewhat more security; and thus we waited quietly whatever Providence should decree. Dark clouds now rose from the west, and the whole atmosphere became filled with a damp vapour. A strong breeze suddenly sprung up from the west, and increased in less than half an hour to a storm. Every moment huge masses of ice around us were dashed against each other, and broken into a thousand fragments. Our little party remained fast on our ice-island, which was tossed to and fro by the waves. We gazed in most painful inactivity on the wild conflict of the elements, expecting every moment to be swallowed up. We had been three long hours in this position, and still the mass of ice beneath us held together, when suddenly it was caught by the storm, and hurled against a large field of ice. The crash was terrific, and the mass beneath us was shattered into fragments. At that dreadful moment, when escape seemed impossible, the impulse of self-preservation implanted in every living being saved us. Instinctively we all sprang at once on the sledges, and urged the dogs to their full speed. They flew across the yielding fragments to the field on which we had been stranded, and safely reached a part of it of firmer character, on which were several hummocks, and where the dogs immediately ceased running, conscious, apparently, that the danger was past. We were saved: we joyfully embraced each other, and united in thanks to God for our preservation from such imminent peril.'

More than once during this trip the party heard from the Tchuktches that land could be seen far away in the northern seas. 'There was a part of the coast,' so said a chief, 'where, from some cliffs near the mouth of a river, one might in a clear summer day descry snow-covered mountains at a great distance to the north; but that in winter it was impossible to see so far.' The part of the coast alluded to was Cape Jakan, which the explorers afterwards visited; but although they 'gazed long and earnestly on the horison, in hopes, as the atmosphere was clear, of discerning some appearance of the northern land,' they 'could see nothing of it.'

After Back's last fruitless voyage in the *Terror*, no further steps towards discovering the north-west passage were made by the British government for seven years. Still, in certain quarters the desire to settle the long-agitated question prevailed as strongly as ever: one final effort, it was thought, should be made to traverse the Polar Sea from its eastern to its western mouth, and many scientific, as well as other considerations, were urged in its favour. The expedition now absent under Sir John Franklin's command was at length determined on; the ships selected—the *Erebus* and *Terror*—were those in which Sir James Ross had so successfully navigated the antarctic seas; and to render them more efficient, each was fitted with a small steam-engine. The route prescribed by official instructions was the track taken by Parry in his first and most fortunate voyage; to push directly westward from Melville Island to Behring's Strait, without deviation to the north or south unless appearances were decidedly in favour of such a departure; and in the event of reaching the Pacific, Sir John was to refresh and refit at the Sandwich Islands, and return to England by way of Cape Horn. The two ships were provided with ample stores for three years; patent fuel instead of coals for economy of stowage; everything, in short, that could promote health, comfort, or the cause of science. They sailed in May 1845, the *Terror* being commanded by Captain Crozier; since which time, with the exception of letters received a few weeks afterwards from some of the officers, and of their having been seen by the Lancaster Sound whalers, nothing whatever has been heard of them.

In 1847 it was felt that some effort should be made to ascertain the fate of the one hundred and thirty-eight individuals embarked in the missing vessels, who might be imprisoned in the ice, awaiting relief and rescue; and in May 1848 Sir James Ross, with Captain Bird as second in command, sailed in the *Enterprise* and *Investigator*, provisioned for three years, with orders to make for Barrow's Strait, and as much farther westward as might be practicable, with such examination of the coast and inlets as might lead to the discovery of Franklin. The complete equipment of this expedition, and the character of its commander, excited high hopes of its success, and great was the disappointment when it returned in November 1849 without the slightest intelligence of those whose fate had become a subject of deep anxiety. The ships had wintered at Leopold Harbour on the north-eastern extremity of Boothia or North Somerset, but with the exception of a survey of a previously-unexplored portion of the north-western coast of the same land, no result of importance was obtained. Illness prevailed among the crews to a greater extent than had been previously experienced, the seasons were uncongenial, and the ice intractable—circumstances all concurring to render the undertaking abortive. A vessel, the *North Star*, was despatched in 1849, as had been arranged, with supplies of provisions, to enable Ross to continue his researches. Her captain was instructed to avoid passing a winter in the ice; but not having returned, the probability is, that he ventured too far to escape being frozen in.

Two other expeditions were despatched also in 1848, with the same object—the relief of Franklin. Sir John Richardson, with willing zeal, came forward once more to assist in the search for his long absent friend; and with Dr Rae—who had been successfully employed in surveying the north-eastern coast for the Hudson's Bay Company in 1846–47—he descended the Mackenzie River to the Polar Sea; but no trace of the missing ships rewarded his exertions.

Meantime the brig *Plover*, Commander Moore, had been sent round to Behring's Strait, there, in company with the *Herald* surveying-ship, to make such advances and explorations among the ice as would best promote the object of discovering the *Erebus* and *Terror*. The result was equally unsatisfactory with that of the expeditions above-mentioned. Portions of the coast previously surveyed by Beechey were again visited; Lieutenant Pullen was sent with a canoe party from Point Barrow to the Mackenzie, to reach the Hudson's Bay Company's forts on that river; a small group of islands was discovered and taken possession of, from which, as Captain Kellett of the *Herald* reports, lofty summits were visible in the distance. He considers it as 'more than probable that the peaks we saw are a continuation of the range of mountains seen by the natives off Cape Jakan (coast of Asia), mentioned by Wrangell in his polar voyages.'

Thus the fate of the missing expedition remained as uncertain as ever; and we have now only to mention briefly the various attempts that are at present (April 1850) in progress for ascertaining it. Captains Collinson and Maclure are on their way to Behring's Strait in the *Enterprise* and *Investigator:* they sailed on the 20th January last: Dr Rae, under the auspices of the Hudson's Bay Company, is exploring overland in the direction of Melville Island: four vessels, the *Resolute* and *Assistance*, and the *Pioneer* and *Intrepid* steamers, now being fitted out at Woolwich, are to sail in May, under command of Captain Austin, to renew the search left incomplete by Sir James Ross: Captain Penny, a whaler, is to explore Wellington Channel with two other ships: Sir John Ross is making preparations to co-operate in the same general service: rewards of £20,000 and £10,000 are offered by government for efficient relief to the Franklin expedition, or information concerning it; and lastly, two or three schooners, equipped by private subscription, are to go out from New York to unite in the work.

Here our brief history of arctic explorations terminates. The results hitherto obtained from them—the extension of whaling grounds apart—are, as will have been remarked, altogether different from those of a pecuniary nature. The astronomer, the geographer, the physicist, the naturalist, the chemist, and science at large, have acquired facts through their means which could have been gained in no other way. The cost has been great, but the consequences will be permanent; and the record of enterprising hardihood, physical endurance, and steady perseverance displayed in overcoming elements the most adverse, will long remain among the worthiest memorials of human enterprise.

[No. 4.]

ANTARCTIC EXPLORATIONS.

BY WALTER WHITE.

FROM the earliest periods of geographical discovery down to the present century, a high degree of mystery has attached to the southern regions of the globe. Long after the seas of the northern hemisphere had been navigated and explored by enterprising adventurers, the ocean south of the equator was regarded with the exaggerated dread which ever attends a low state of knowledge. It was there that nature kept some of her profoundest secrets; and during several generations, man shrank from the attempt to penetrate them. Not to mention the vague speculations of Ptolemy and others of the ancient philosophers, we may commence with the incident recorded by Arabian writers, that in 1147, about the time of the second Crusade, eight individuals sailed to discover the limits of the 'Sea of Darkness,' as the Atlantic was then called. They touched at an island on the way, from the natives of which they heard rumours of a 'dense gloom' to the southward, and were so terrified at the prospect, that they abandoned the voyage. Two Genoese made a similar attempt in 1291, and were never afterwards heard of. In maps of this period Africa is made to terminate north of the equator; a curious one preserved in the library at Turin exhibits the outlines of the then known parts of the world, and an explanatory note, stating, 'Besides these three parts of the world, there is beyond the ocean a *fourth*, which the extreme heat of the sun prohibits our being acquainted with, and on the confines of which is the country of the fabulous antipodes.' In the maps by Picigano, about 1367, Africa is seen similarly defrauded of its fair proportions; but—and the fact is remarkable—these maps exhibit a western continent named Antilia, which is supposed to represent South America: the same outlines also occur in Andrea Bianco's map of 1436.

The fifteenth century gave birth to a more inquiring and adventurous spirit. Encouraged by Don Henry, Portuguese navigators doubled Cape Bojador, in 1418, just after the battle of Agincourt, and crept timidly down towards the supposed uninhabitable torrid zone. In 1433, the feat was repeated by Gilianez of Lagos; and within the next twenty years, several expeditions had visited Guinea and the Gold Coast. At length, in 1486, while numbers in England were mourning the field of Bosworth and the last of the Plantagenets, Bartholomew Diaz, a knight of King John's household, sailed with two caravels of fifty tons each, and a small storeship, to attempt further discoveries. He touched on the coast of Africa, and set up a stone pillar at a point beyond the limit of any former voyage, and then sailing boldly across the ocean, saw land no more until he was forty leagues to the eastward of its southern extremity—a dense mist, peculiar to that latitude at certain seasons, had concealed it from his sight. He had reached what is now known as Algoa Bay. The crew were unwilling to proceed; but Diaz prevailed on them to sail twenty-five leagues farther, where the coast was seen still trending to the eastward. On returning, he saw the end of the land—a view that gladdened and rewarded him for his labour and anxieties; and set up a pillar on the shore to establish the Portuguese claim to the discovery. He had now found the route from the Atlantic to the Indian Ocean, then, however, regarded with terror, from the violent storms which almost constantly prevailed. It was from these that Diaz called the remote promontory 'Il Cabo dos Tormentos,' a designation which it was not long to retain, for, on the return of the adventurers to Lisbon in December 1487, as related by Camoens—

> 'At Lisboa's court they told their dread escape,
> And from her raging tempests, named the Cape.
> Thou southmost Point, the joyful king exclaimed,
> Cape of Good Hope be thou for ever named.'

In October 1492, Columbus led the way to tropical America: thus within a short period two great routes were opened to the mysterious southern regions. Vasco de Gama's voyage followed; with a small fleet he rounded the Cape on which such hopes were built, and reached India. According to the accounts given, it was no easy task. 'The waves,' says the narrator, 'rose like mountains in height, his ships were heaved up to the clouds, and now appeared as precipitated by circling whirlpools to the bed of the ocean. The winds were piercing cold, and so boisterous, that the pilot's voice could seldom be heard, whilst a dismal and almost continual darkness, which at that tempestuous season involves those seas, added greatly to the danger. Sometimes the gale drove them to the southward, at other times they were obliged to stand on the tack, and yield to its fury, preserving what they had gained with the greatest difficulty. During any gloomy interval of the storm, the sailors, wearied out with fatigue, and abandoned to despair, surrounded Gama, begging he would not devote himself and crew to so dreadful a death. They exclaimed that the gale could no longer be weathered; that every one must be buried in the waves if they continued to proceed. The firmness of the admiral could not be shaken, and a formidable conspiracy was immediately formed against him; but of this desperate proceeding he was informed by his brother Paulo. The conspirators and all the pilots were immediately put in irons; whilst Gama, assisted by his brother, and the few who remained steadfast in their duty, stood night and day to the helm. Providence rewarded his heroism, and at length, on Wednesday the 20th of November, all the squadron doubled this tremendous promontory.'

Several of the companions of Columbus figure prominently in the history of coasting voyages along the American continent. Vincent Yanez Pinzon was the first to cross the line in the western seas; he discovered Brazil a few months before it was seen by Cabral. In the previous year, 1499, Hojeda had sailed to make discoveries with Amerigo Vespucci as pilot, and to the latter must perhaps be accorded the merit of the earliest antarctic explorations. He had made two voyages in the Spanish service; his third, undertaken in May 1501, with 'the daring project of advancing as near as possible to the antarctic pole,' was under the auspices of Emmanuel, king of Portugal. The party were embarked in three small vessels, and after sixty-seven days' sailing, saw the coast of Brazil. 'This long run,' says Vespucci, 'we made in great distress, continually beaten by rain and tempests, attended for six weeks with so thick a darkness, that we all gave ourselves for lost. Our pilots were at their wits' end, not knowing in what part of the world we were. But the skill I possessed in astronomy and cosmography helped me to direct our course, and my success increased the crews' confidence in me, as a very extraordinary person.' They coasted along, landing occasionally, and staying a month at anchor to refresh, and losing some of the crew, who were eaten by the natives, until, as recorded, 'we had passed the tropic of Capricorn, and brought the north-pole star below the horizon. We then began to regulate our course by the stars of the southern hemisphere, which we found larger and brighter than those of the northern;' and Vespucci boasts that he was the first since Adam and Eve to view the constellation of the Southern Cross. In April 1502 they had reached the latitude of 52 degrees south. 'Here,' he continues, 'the sea ran so high, that the whole crew expected to perish, it being now winter in those parts, and the nights more than fifteen hours long. On the first day of April I discovered a Terra Australis, which we coasted for twenty leagues. We found it all a bold shore, without seeing any port or inhabitants. Here we found it so cold, that none of us could endure it, and the fogs so thick, that we could not see from the one ship to the other. The captain, alarmed at the dangers the ships ran in those seas, resolved to return towards the equator; and lucky it was he did so, for on the two following days the storm was so violent, that had we continued our intended course, in all probability the squadron had been lost in thick fogs during these long nights.' In September of the same year Vespucci was again at Lisbon; when he turned back, he was probably somewhere between the Falkland Islands and the mainland; and had he persevered towards the pole, the southern cape of the new, as well as of the old continent, would have been discovered by the Portuguese.

The next expedition was conducted by Juan Diaz de Solis, one of the most able navigators of that day: he sailed in 1514, and on coming to the great estuary of the Rio de la Plata, or *mar dulce*, as he named it, he thought he had reached the much-desired passage to the western ocean. He ascended the river for some distance; but his voyage came to an unhappy termination: one day, while on shore, he was captured with five of his crew, and eaten by the natives. From his abilities, we may conclude that had this catastrophe not occurred, he would have succeeded in the object of his search.

Balboa's discovery of the great South Sea from 'a peak in Darien' in 1513, the same year that Flodden Field was fought, had excited the adventurous spirits of that adventurous age with eager desires to find a passage from the one ocean to the other: hence the numerous but abortive coasting voyages in the Gulf of Mexico and to the southward. The expedition under Magellan, which sailed from San Lucar in September 1519, when Luther was setting Germany in a blaze with the fire of the Reformation, had the same object: he was appointed commander of a fleet of five vessels, the largest not more than 120 tons burthen. On arriving in Port St Julian, after the then usually tedious voyage across the Atlantic, a consultation was held as to their means and prospects: nearly every voice was raised against proceeding: some feared the length of the voyage, others dreaded being abandoned far from their native country. Magellan, however, determined to winter in the port, and gave orders for the provisions to be issued under allowance; 'whereupon,' according to Herrera, 'the people, on account of the great cold, begged him that since the country was found to extend itself towards the antarctic, without showing a hope of finding the cape of this land, nor any strait; and as the winter was setting in severe, and some men dead for want, that he would increase the allowance, or return back; alleging that it was not the king's intention that they should seek out what was impossible, and that it was enough to have got where none had ever been; adding, that, going farther towards the pole, some furious wind might drive them where they should not get away, and all perish.'

'Magalhaens, who was a ready man, and presently hit on a remedy for whatever incident occurred, said that he was very ready to die, or to fulfil what he had promised. He said that the king had ordered him the voyage which was to be performed; and that, at all events, he was to sail till he found the end of that land, or some strait, which they could not fail of doing; and though wintering seemed to be attended with difficulties, there could be none, when the spring set in, to proceed forward, discovering the coasts of the continent under the antarctic pole, being assured that they must come to a place where a day lasted three months: that he was astonished that men, and Spaniards, could have so much sluggishness.' The brave leader ended by avowing his determination to die rather 'than shamefully to return back;' and by the force of his example and encouraging words, succeeded in repressing the discontent for a time.

While lying here, several of the natives came down to the anchorage; their stature was such, that the Spaniards regarded them as giants, and from their rude contrivances for shoes, named them Patagones, or *clumsy-hoofed;* an appellation which they still retain. Exploring parties were sent out from time to time to examine the inlets along the coast: one of these parties lost their vessel, and before they could regain the port, endured so great hardships from want of food and severity of the climate, as to be scarcely recognisable in their wretched and emaciated condition. Discontent again broke out: some of the ringleaders were condemned to be left on shore—a miserable fate: a mutinous captain was stabbed, and another condemned to be hanged with a youth of his crew: 'and because they had no executioner, the boy, to save his own life, accepted of the office, and hung his master, and quartered him.' Refractoriness on the part of the crews was one of the greatest obstacles which the leaders of early voyages had to contend against.

The fleet put to sea a second time in October 1520, and shortly afterwards came to the mouth of a great strait, which ran so far into the land, as flattered all on board must be the wished-for passage. Considering the question as settled, the pilots demanded to return to Spain for larger and better-furnished vessels wherewith to enter on the unknown navigation; but Magellan replied, 'that if even he thought they could be reduced to the necessity of eating the hides which were on the yards, he would go on to discover what he had promised the emperor; for he trusted God would assist them, and bring them to a good conclusion.' One of the vessels was wrecked, the crew of another abandoned the enterprise, so that but three ships were left to explore the strait. Magellan, however, bore up against the difficulties of an intricate navigation. 'While sailing along,' says Herrera, 'they observed the land here was very ragged and cold; and because they saw in the night many fires, it was named Terra del Fuego.' At length, 'on the 27th November, he sailed into the great South Sea, giving infinite thanks to God that he had permitted him to find what was so much desired, and that he was the first who had found the passage so much sought after. Whereby the memory of this excellent captain shall be eternally celebrated.'

Although Magellan had been anticipated by Balboa in embarking on the waters of the ocean, to which he gave the name of Pacific, he was the first European to navigate it with ships. By a singular fatality, he chose a track on which, during more than 3000 miles, he saw no other land than two insignificant islets, while his crew were dispirited and half-starved:

'Waste and wild
The view! On the same sunshine o'er the waves
The murmuring mariners, with languid eye,
E'en till the heart is sick, gaze day by day.'

Their chief, as is well known, did not live to reap the fruit of his labours, having been killed in a battle with the natives of one of the Philippine Islands, and but one of his vessels returned to Europe. This voyage was the more remarkable, as being the first circumnavigation of the globe, and the first occasion of seamen finding the loss of a day in their reckoning; a fact which caused much surprise at that time, and baffled the learned in their attempts to account for it.

Pigafetta, a contemporary historian, says of this voyage, 'These were mariners who surely merited an eternal memory, more justly than the Argonauts of old. The ship, too, undoubtedly deserved far better to be placed among the stars than their ship Argo: for this, our wonderful ship, taking her departure from the Straits of Gibraltar, and sailing southwards through the great ocean towards the Antarctic Pole, and then turning west, followed that course so long, that, passing round, she came into the east, and thence again into the west, not by sailing back, but proceeding constantly forward; so compassing about the globe of the world, until she marvellously regained her native country, Spain, and the port from which she departed, Seville.'

Several other expeditions followed, undertaken by adventurers on their own account, or with the sanction of the governmental authorities. Loaysa was sent out with a fleet by Spain in 1526, to lay claim to the Moluccas; and, according to some accounts, Huces, one of his captains, was driven so far to the southward, that he saw the end of the land. But so much disaster, misery, and privation attended lengthened voyages at that early period, that no other important expedition sailed until the famous one under Drake in 1577. The time had come for Englishmen to exhibit their skill and hardihood in distant navigation, and the circumstances were such as to favour and stimulate their manifestation.

Pope Alexander VI. had decided by a bull that a line drawn from the north pole to the south, 100 leagues west of the Azores, should be the dividing line between the possessions of the Spaniards and the Portuguese, to whom all the new discoveries were to belong; a decision which produced the remark from the king of France, 'Since the kings of Spain and Portugal divide the whole world between them, I wish that they would show me the will of our father Adam, that I might see in what terms he has constituted them sole heirs.' Supported by such authority, the two powers often came into conflict; and the jealous and arrogant spirit displayed by Spain towards other competitors, tended to provoke a formidable rivalry on the part of such a people as the English, animated by an ardent spirit of enterprise. To prevent others from following on their tracks, the Spaniards for a long time kept their maps and charts studiously secret—a mean and selfish policy, in which they were afterwards imitated by the Dutch with respect to their eastern possessions, and also by the Hudson's Bay Company regarding theirs in the north.

Drake sailed from Plymouth in December 1577, with a fleet of five vessels, the largest 100 tons burthen. In August of the following year he entered the Straits of Magellan, greatly to the surprise and disappointment of the Spaniards, who, until then, had believed that no stranger would venture on or succeed in so hazardous an enterprise. He effected the passage in seventeen days: on reaching the western mouth, the fleet was separated by a tempest, and Drake was left with only two vessels to prosecute his voyage. The foul weather, however, was the cause of an interesting incident:—'I remember,' says Sir R. Hawkins in his narrative, 'that Sir Francis Drake told me, that having shot the Straits, a storme took him first at north-west, and after vered about to south-west, which continued with him many dayes, with that extremitie, that he could not open any sayle, and that at the end of the storme he found himselfe in fiftie degrees, which was sufficient testimony and proof that he was beaten round about the Straits, for the least height of the Straits is in fiftie-two degrees and fiftie minutes, in which stand the two entrances or mouths. And moreover, he said, that standing about when the winde changed, he was not well able to double the southermost iland, and so anchored under the lee of it; and going ashoare, carried a compasse with him, and seeking out the southermost part of the iland, cast himselfe downe upon the uttermost point groveling, and so reached out his body over it. Presently he imbarked, and then recounted unto his people that he had beene upon the southermost knowne land in the world, and more further to the southwards upon it than any of them, yea or any man as yet knowne.' Here the gallant captain saw 'the Atlantic Ocean and the South Sea meet in a large and free scope:' he was detained by the storm fifty-one days, and occupied himself in observing the manners of the natives, to whose islands he gave the name of Elizabethides. His further exploits do not fall within our purpose; suffice it, that he was the first Englishman who sailed round the world, and completed the voyage in two years and ten months.

The first attempts of the English to sail round the Cape of Good Hope were made in 1591 with three vessels, one of which only, Sir James Lancaster's, reached India. Shortly afterwards, when Philip of Spain invaded Holland, the Dutch resolved to attack the Spanish possessions in America, and in 1598 sent out Oliver Van Noort and an English pilot named Mellish with four vessels: they were the pioneers of that commercial nation in the southern regions. Another fleet of five ships sailed from Rotterdam in the same year: one of the captains, Sebald de Weert, discovered a group of islands which for a long time bore his name; they are now better known as the Falklands. Old Purchas relates that Theodore Gerards (Gerritz), 'one of that fleet, was carried by tempest, as they write, to 64 degrees south, in which height the country was mountainous, and covered with snow, looking like Norway. It seemed to extend to the Islands of Salomon.' This mountainous land is now supposed to be the South Shetlands, which were rediscovered some 200 years after the event above recorded. The Hollanders were not slow in pushing their trade into the new countries; the Dutch East India Company despatched a fleet under Spilberg, and claimed the monopoly of trade to India by the Cape of Good Hope and the Straits of Magellan, a restriction unfavourable to other merchants, by whom it was complained of. The States-General, to resolve the difficulty, and promote discovery, declared that the discoverer of a new passage to India should be rewarded with the profit of the first four voyages. The opportunity was not neglected: Le Maire, a sagacious and wealthy merchant of Amsterdam, who had studied the subject, came to the conclusion that such a passage existed, and took measures to verify his opinion. Two ships, the *Unity* and the *Horn*, were privately equipped, and sent out under command of William Schouten and Le Maire's son in 1615: in November they anchored in Port Desire for refreshment and repairs, and while here, the *Horn* was accidentally burnt. They resumed their voyage in January 1616, the year in which Baffin's Bay was discovered, and on 'the 24th, in the forenoon, saw land a-starboard, about a league's distance, stretching out east and south, with very high hills, all covered with ice; and then other land bearing east from it, high and rugged as the former. They guessed the lands they had in these two prospects lay about eight leagues asunder, and that there might be a good passage between them, because of a pretty brisk current that ran southward along by them. They saw an incredible number of penguins, and such large shoals of whales, that they were forced to proceed with great caution, for fear they should run their ship upon them.'

'The 25th, in the forenoon, they got close up by the east land; this they called States Land, and to that which lay west they gave the name of Maurice Land. In the evening, having a south-west wind, they steered southwards, meeting with mighty waves, that came rolling along before the wind, and the depth of the water to the leeward from them, which appeared by some very evident signs, gave them a full assurance that the great South Sea was now before them, into which they had almost made their way by a passage of their own discovering. The 29th they saw land again; this was the high hilly land, covered with snow, that lay southward from the Magellanic Straits, ending in a sharp point, which they called Cape Horn, and now they gathered full assurance that the way was open into the South Sea. The 12th of February they plainly discovered the Magellanic Straits lying east of them; and therefore, now being secure of their happy new discovery, they rendered thanks to good fortune in a cup of wine, which went three times round the company.' If the accounts concerning Huces and Drake are to be depended on, Cape Horn had been twice before discovered in the course of the preceding century.

Le Maire's name was given to the newly-discovered strait, and thus the utmost southern point of the American continent was made known, and an open passage found from the Atlantic to the Pacific Ocean. An enterprise so well considered, and successfully carried out, should have had a satisfactory termination. But on the arrival of the *Unity* at Bantam in October, the president of the Dutch East India Company confiscated the vessel and her cargo, declaring Schouten and his companions to be unlawful traders, and bade them seek redress in Holland. Spilberg's ships were then about to sail on their homeward voyage, and several of the discomfited adventurers took passage by them. Le Maire died from vexation after they had been two weeks at sea; and Schouten reached Holland in July 1617, having accomplished his journey round the world in two years and eighteen days, and failed to obtain redress for the injustice of which he had been the victim. His voyage affords an instance of sagacious thought finding its confirmation in experience.

Another Spanish expedition under the Nodals, accompanied by Dutch pilots, sailed in 1618 to verify Schouten's discoveries: it returned, after surveying the coasts of Terra del Fuego. And in 1623, the Nassau fleet, composed of eleven Dutch ships of war, arrived in the same latitudes: the commander, Jaques le Hermite, found that several passages existed by which the Pacific could be reached without doubling the Horn or passing through the Straits—a fact confirmed by the late surveying voyage of Captain King in the *Beagle*. One of Hermite's vessels went as high as 60°, and rounded the Cape without once seeing it.

Meantime Pedro Fernandez de Quiros, in a memorial to the viceroy of Peru, had requested permission to 'plough up the waters of the unknown sea, and to seek out the undiscovered lands around the antarctic pole, the centre of that horison.'

> 'With De Quiros to the south
> Still urge the way, if yet some continent
> Stretch to its dusky pole, with nations spread,
> Forests, and hills, and streams.'

The north, he shows, was known up to the 70th degree of latitude, while 'of the south part is discovered to 55 degrees only, passing the Strait of Magalhaens; and to 35 degrees, in which is the Cape of Good Hope; or 40 degrees and a little more, to which ships go in doubling it. Now are wanting the rest which remain from these, and from this parallel and to the west, from a lower latitude, to 90 degrees, to know if it is land or water, or what part there is of both.' It was supposed, from the voyages that had been made to the Philippines and other islands of the Pacific, that a great land existed towards the pole, 'the antipodes to the greater part of Europe, Africa, and Asia, where from 20 degrees to 60 degrees, God has made men so useful.' Quiros sailed from Lima in 1605 in company with Torres: he discovered twenty-three islands, among which his Sagittaria and Encarnacion are believed to be Tahiti and Pitcairn's Island. And so confident was he that a greater extent of land would be found, that on his return, in his communication to Philip II., he declared, 'in the southern parts lies hid a quarter of the globe.'

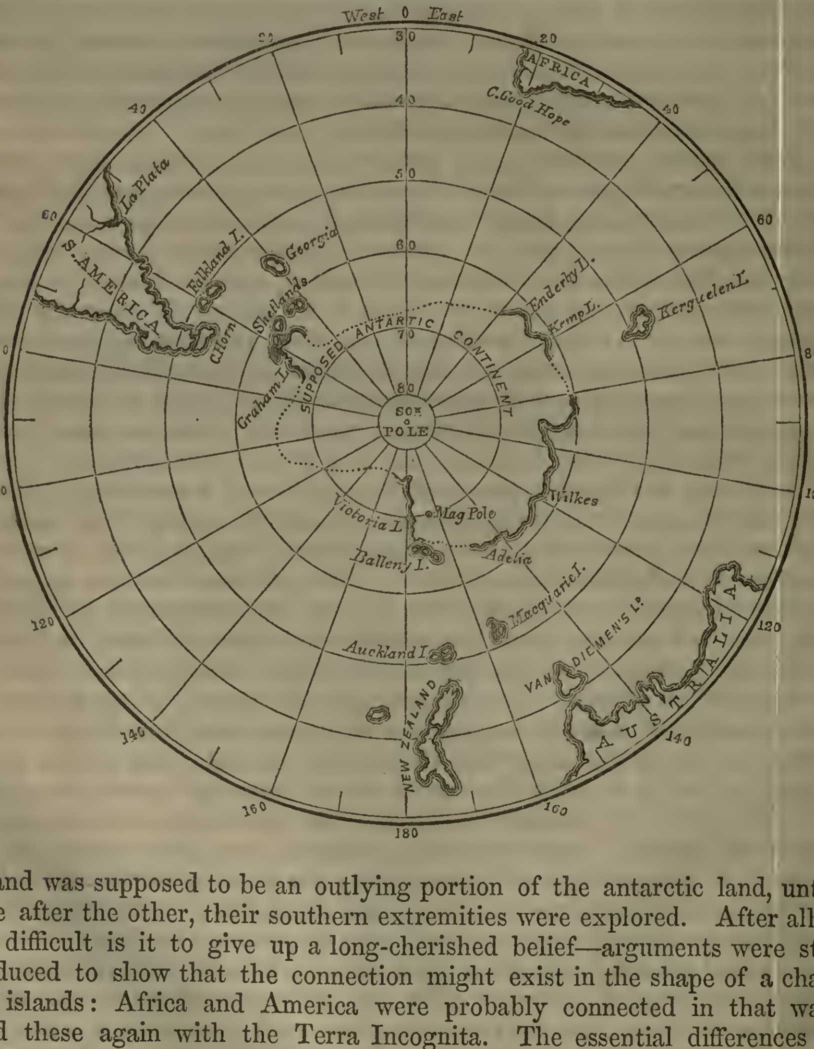
In 1606, Torres saw another great land, now known as Australia, which, with some show of probability, might have been the continent imagined by his companion. Within the next twenty-five years, the north and west shores of that vast island were surveyed by Dutch navigators, and there is reason to believe that it had been visited by the Spaniards and Portuguese nearly a century earlier, as it is laid down in maps drawn about the year 1550, which are preserved in the British Museum; but in accordance with the jealous policy of those people, the knowledge of it was kept secret.

For some time this new discovery was supposed to be the great south land; and in 1642, Van Diemen, the governor of Batavia, sent Tasman to make explorations. In this voyage the geography of the region was determined; the extreme southern portion of the land was sailed round, and named after the governor, and its disconnection with an Austral continent conclusively proved. Tasman afterwards discovered New Zealand; and possessed with the ideas of the period, he imagined that this remote island stretched away, and united with the Staten Land of Schouten and Le Maire at Terra del Fuego, and hoped it was 'part of the unknown south continent.' As an acknowledgment of Tasman's services by the States-General, the large island was named New Holland.

Those daring sea-rovers, the Bucaneers, while pushing their lawless cruises, for greater part of the seventeenth century, wherever the hope of plunder led them, contributed materially, though indirectly, to extend the limits of geographical research. Dampier and Wafer were among the party who marched across the Isthmus of Panama; and embarking in several canoes which they had stolen, rowed out to sea, and made prize of a vessel lying at anchor. Emboldened by success, they attacked and took larger ships, and in these traversed the Pacific Ocean. One of their captures was turned adrift as useless, with seven hundred pigs of metal on board, which they supposed to be lead; afterwards, when they came to make bullets from a lump which they had kept, the lead proved to be silver. Desirous of re-entering the Atlantic, they stretched boldly to the southwards till they met with ice, and doubled Cape Horn; and inspired so much confidence by their resolute perseverance, that a voyage round South America came to be regarded with diminished apprehension. Dampier was afterwards appointed to the command of a vessel fitted out by the government of William III., in which he made further discoveries in New Holland and other southern countries. The war which broke out between England and Spain in 1739 led to Anson's famous voyage, which, though in many respects unfortunate, widened the boundaries of geographical knowledge. The wreck of one of the squadron, the *Wager*, on the coast of Terra del Fuego, although it gave the survivors an intimate knowledge of the country, will always be remembered as a most melancholy incident in the annals of disaster. 'Nothing can be imagined,' says the historian of the expedition, 'more savage and gloomy than the whole aspect of this coast.' In doubling the Cape, 'we had a continual succession of such tempestuous weather, as surprised the oldest and most experienced mariners on board, and obliged them to confess that what they had hitherto called storms were inconsiderable gales compared with the violence of these winds, which raised such short, and, at the same time, such mountainous waves, as greatly surpassed in danger all seas known in any other part of the globe.'

And he laments that 'the squadron would be separated never to unite again, and that this day of our passage would be the last cheerful day that the greatest part of us would ever live to enjoy.'

Up to this period, and for some time afterwards, the idea of a great southern continent was still entertained: philosophers argued in favour of it, for without a mass of land at the antipodes to counterbalance the preponderance in the north, the inequality of weight would cause the earth to rotate in the opposite direction! Among the maps published in 'Purchas's Pilgrims' is one which represents South America as terminating at the Strait of Magellan, by which it is separated from a huge continent, larger apparently than any other division of the world, and named *Terra Australis Incognita;* and that which accompanies Dampier's narrative contains the same delineation, but in a less exaggerated form. Every newly-discovered island was supposed to be an outlying portion of the antarctic land, until, one after the other, their southern extremities were explored. After all—so difficult is it to give up a long-cherished belief—arguments were still adduced to show that the connection might exist in the shape of a chain of islands: Africa and America were probably connected in that way, and these again with the Terra Incognita. The essential differences of natural phenomena, as observed in the north and in the south, were



also matter for speculation, and not a little error was mixed up with the truth. Acosta's treatise affords numerous instances. 'Many in Europe,' he writes, 'demand of what forme and fashion heaven is in the southerne part; for that there is no certaintie found in ancient books, who, although they grant there is a heaven on this other part of the world, yet come they not to any knowledge of the form thereof.' Ice was met with in lower latitudes than in the north; the seasons were less genial; the climate of Staten Land and Terra del Fuego would bear no comparison with that of countries lying in a similar latitude in the opposite zone. One reason assigned for the difference was, that the sun remained eight days longer in the northern than in the southern hemisphere, and that the north was nearer to the sun during winter. These, with many other absurd notions, were, however, to disappear before the increasing intelligence of the period to which we are now approaching.

In 1764, Commodore Byron, who had been wrecked in the *Wager*, sailed with two armed vessels 'to make discoveries of countries hitherto unknown;' for, as stated in his instructions, 'there was reason to believe that lands or islands of great extent, hitherto unvisited by any European power, may be found in the Atlantic Ocean between the Cape of Good Hope and the Magellanic Strait, within the latitudes convenient for navigation.' This voyage lasted twenty-two months, without enlarging the limits of southern exploration. The expedition by Wallis and Carteret in the *Dolphin* and *Swallow* followed in 1766. The ships were four months in passing the straits; and having been separated in a gale, did not meet again during the cruise. Carteret rediscovered Pitcairn's Island, and Wallis Tahiti. The latter was unable to account for the natives being somewhat acquainted with the use of iron, but the prior discovery by Quiros furnishes a sufficient explanation. Bougainville's second voyage was also undertaken at the same time.

We come now to the voyages of Captain Cook: these had a definite scientific object. Astronomers were desirous that the transit of Venus over the sun's disk, which took place in 1769, should be observed on the other side of the world as well as in Europe: the determination of some highly-important astronomical questions depended on it. Wallis, who had just returned, recommended a bay in Tahiti as a suitable locality for the purpose. A strong collier ship, the *Endeavour*, was selected; and in August 1768 Cook sailed. Banks and Solander were on board as naturalists. They were thirty-four days in beating round the Horn; and after observing the transit, steered for New Zealand, and disproved Tasman's supposition as to the connection of those islands with the southern continent. The eastern coast of New Holland was afterwards surveyed, from the spot where the Dutch navigator left off, to Torres' Straits, an extent of more than 2000 miles. Cook landed and took possession of the country, giving it the name of New South Wales, and returned to England in 1770, after an absence of two years and eleven months.

A French expedition went out shortly afterwards, commanded by the unfortunate Marion, who was eaten by the New Zealanders. One of his lieutenants, Kerguelen, discovered land in 50° 5′ south in February 1772, and hastened back to France with glowing accounts of an antarctic continent. This was the most southerly land then known in the Atlantic. Cook touched at it during his third voyage in 1776, and called it Desolation Island; but it is generally known by the name of its first discoverer.

Although Cook had shown that New Zealand was not united to the *Terra Australis Incognita*, it was still thought that a continent would be found. An expedition to search for it was sanctioned by the government; and Cook went out a second time with two vessels, the *Resolution* and *Adventure*, the latter commanded by Captain Furneaux, who had held the post of lieutenant under Wallis. To make the voyage as complete as possible, a number of scientific men and skilled artists were attached to the vessels, and every means taken to promote the health of the crews. They sailed in July 1772; and in January of the following year were in 67° 15′ south latitude, where further progress was stopped by ice, and for the first time the aurora australis was observed. After a run of 11,000 miles, without once seeing land, Cook anchored at New Zealand to refit, from whence he again advanced towards the antarctic pole, in such a direction as to take advantage of the currents setting from west to east. On the 29th January 1774, when in latitude 71° 10′ south, longitude 106° 54′ west, a point far beyond all those previously attained, he was stopped once more by ice, extending, as he believed, to the pole; yet from the number of birds flying about the ship, he judged there must be land behind the ice: and he 'who had ambition not only to go farther than any one had gone before, but as far as it was possible for man to go,' was compelled to renounce his hope of penetrating nearer to the south. He subsequently traversed the whole of the Southern Pacific, the first time the feat had ever been accomplished; rounded Cape Horn with 'more calms than storms;' surveyed the islands of Terra del Fuego; and started on a high latitude to cross the South Atlantic in January 1775. On the 14th land was seen; and on the 17th the great navigator landed to take possession, although he did not think 'that any one would ever be benefited by the discovery.' He named it Isle of Georgia, and describes it as 'savage and horrible. The wild rocks raised their lofty summits till they were lost in the clouds, and the valleys lay covered with everlasting snow. Not a tree was to be seen, not a shrub even big enough to make a toothpick.'

'Who would have thought,' he adds, 'that an island of no greater extent than this, situated between the latitude of 54° and 55°, should in the very height of summer be in a manner wholly covered many fathoms deep with frozen snow?' Although he saw much ice, he concluded that a greater extent of land was required for its formation than here seen, and he hoped to discover a continent. Yet he says, 'I must confess the disappointment I now met with did not affect me much; for to judge of the bulk by the sample, it would not be worth the discovery.'

In this part of his cruise Cook had no intention of going higher than 60 degrees, unless induced to do so by real signs of land. On the 30th, when in latitude 59° 13′ 30″ south, islands were seen, which he called Sandwich Land and Southern Thule, 'because it is the most southern land that has ever yet been discovered.' The great navigator shrewdly conjectured that a greater expanse of land existed nearer the pole, and that it projected most towards the north in the region of the South Atlantic and Indian Oceans, as more ice was always found there than in the South

Pacific. Yet he declared himself 'bold enough to say that no man will ever venture farther than I have done, and that the lands which lie to the south will never be explored. . . . . Lands doomed by nature to perpetual frigidness; never to feel the warmth of the sun's rays; whose horrible and savage aspect I have not words to describe.'

Subsequent events have proved that in these respects Cook was simply mistaken. Not so in his explorations. His determination of positions and accuracy of surveys are beyond all praise: few persons have rendered greater services to the science of geography. He was, besides, the first to prove that remote expeditions did not necessarily involve waste of life; for on returning to England in 1775, after a voyage of three years and eighteen days, he brought back the whole of his crew in health, with the exception of four lost by casualties. After this, publishers left the *Terra Australis Incognita* out of their maps.

A contemporary of Cook's, Alexander Dalrymple, afterwards hydrographer to the Admiralty, had long entertained a belief in the existence of an antarctic continent, and frequently importuned the government to send him out with an expedition to colonise the probable country. He drew up a singular code of laws by which the settlement was to be governed: women were to have equal privileges with men; all lawyers were to be subjected to perpetual imprisonment; bachelors and maids to be taxed; none but copper money: and accounts of the government expenses to be submitted to the public every Sunday. Had this project been realised within the antarctic circle, Dalrymple would have proved himself a coloniser of no common order.

After Cook's second voyage, no further advance was made in antarctic exploration until within the first quarter of the present century. In 1818, Captain Smith, while on a course from Monte Video to Valparaiso, saw a long line of coast, as it appeared to him, in latitude 62°. He reported the fact to the commander of the *Andromache*, then lying in the port to which he was bound, who sent an officer to survey the land. It was found to consist of a group of twelve principal islands, surrounded by countless rocks and rocky islets, which are now known as the South Shetlands, of which Gerritz caught a glimpse in 1599. In 1820, Weddell discovered the South Orkneys; and in 1821, Bellinghausen, a Russian in command of the *Vostok*, penetrated as far as 69 degrees—the first time that the antarctic circle had been crossed since Cook's voyage. Powell and Palmer, two Englishmen, also made some explorations about this period. In 1822, an expedition sailed from the Downs which reminds one of the enterprises of former days in the small size of the vessels, a brig and cutter; the one 160 tons, the other 65. They were commanded by Weddell and Brisbane, and were provisioned for a sealing voyage of two years. In the first part of their cruise they proved the non-existence of the supposed continent connecting Sandwich Land and the South Shetlands; and on the 18th February 1823, were in latitude 72° 24′, where not a particle of ice was to be seen; and on the 20th, in 74° 15′, 214 miles beyond Cook's farthest. Here, although the sea continued open, and Weddell believed that no more land lay to the south to prevent access to the pole, he judged it most prudent, from the lateness of the season, to return. On anchoring at South Georgia in March, he describes the sight of that desolate land as a gladness to their eyes after their lengthened and daring cruise.

The trade to this island, which began soon after Cook's report concerning it was published, has shown how fallacious were his predictions. In the course of a few years, it furnished more than a million of seal-skins and 20,000 tuns of oil to the London market; and Kerguelen Island has proved not less profitable. Mr Weddell states that 'during the time these two islands have been resorted to for the purposes of trade, more than 2000 tons of shipping, and from 200 to 300 seamen, have been employed annually in the traffic.' From the South Shetlands also, in 1821 and 1822, 940 tuns of oil and 320,000 seal-skins were obtained.

In 1829, the South Shetlands were visited by the *Chanticleer* surveying-ship: in common with all the other lands of the Antarctic Ocean, they were found to be volcanic; some of them rising to a height of between 6000 and 7000 feet. Lieutenant Kendal describes them as 'the most dreary aspect of barrenness ever beheld.' No vegetation was to be seen except a few lichens; but penguins, pintados, and sea-leopards, were numerous. The ship was moored in a small cove in Deception Island for several weeks, and an observatory built on the shore, while the boats were employed in the survey. The volcanic force was still active; 150 jets of steam could be seen from the *Chanticleer's* anchorage. Surveying in such latitudes is, as Lieutenant Kendal says, 'cheerless work. The fogs were so frequent, that for the first ten days we saw neither sun nor star; and it was, withal, so raw and cold, that I do not recollect having suffered more at any time in the arctic regions even at the lowest range of the thermometer.'

Within the twelve following years are comprised the greatest achievements in antarctic research: Messrs Enderby sent out a brig and cutter, the *Tula* and *Lively*, under Captain Biscoe, on a sealing voyage in July 1830. In the course of December he discovered an island in latitude 58° 25′, longitude 26° 55′, which he describes as 'terrific, being nothing more than a complete rock, covered with ice, snow, and heavy clouds, so that it was difficult to distinguish one from the other.' In January 1831 he crossed Cook's track of 1773, and found the field ice in precisely the position where that celebrated explorer had left it; signs of land had been for some time visible, and on the 27th a considerable extent of coast was seen in latitude 65° 57′, longitude 47° 20′ east. In the night an aurora australis appeared 'at times rolling,' to quote Biscoe's words, 'as it were, over our heads in the form of beautiful columns, then as suddenly changing like the fringe of a curtain, and again shooting across the hemisphere like a serpent; frequently appearing not many yards above our heads, and decidedly within our atmosphere. It was by much the most magnificent phenomenon of the kind that I ever witnessed; and although the vessel was in considerable danger, running with a smart breeze, and much beset, the people could scarcely be kept from looking at the heavens instead of attending to the course.'

Great efforts were made to reach the land, which lies on the antarctic circle, but the opposition of ice and currents was too powerful to be overcome. The health of the crew suffered from cold and exposure; and in April, while on the passage to Van Diemen's Land, two men died, and the others were so weak, that with the exception of the three officers, only one man and a boy were able to do duty. Undeterred by these casualties, Biscoe sailed again for the south in January 1832, taking a south-easterly course, which, in the following month, in latitude 67° 1′, longitude 71° 48′ west, brought him to an island, the westernmost of a chain lying off a high main coast now known as Graham's Land. He landed on the 21st February, and took possession in the name of his majesty William IV.

From this group, sometimes called Biscoe's Range, the discoverer touched at the South Shetlands, where he narrowly escaped shipwreck, and sailed for St Catherine's in Brazil, on which route the *Lively* was lost on one of the Falkland Islands. His voyage is remarkable as having comprised the circumnavigation of the south pole, and two cruises within the antarctic circle, as well as for the new lands which it brought to light. It affords another instructive instance of what may be accomplished by proper skill and courage with comparatively small means.

Another sealing expedition, a schooner and cutter in charge of Captain Balleny, was sent out by Messrs Enderby in July 1838. This was also successful in discovering land, a group of five islands, now called Balleny Isles, one of which rises with a splendid peak 12,000 feet above the sea-level. The vessels encountered much severe weather; and on the 24th March, at midnight, during the return voyage, the cutter burned a blue light, which was answered from the schooner; but the heavy sea prevented communication. The next morning the little cutter was nowhere to be seen: she had perished with all her crew; and it was not without much difficulty that Balleny saved his vessel from a similar fate, and reached London in September 1839.

In 1837, the French government sent out an expedition under Rear-Admiral D'Urville, an eminent explorer, who had already made three voyages round the world. Two corvettes, the *Astrolabe* and *Zélée*, sailed from Toulon, and by the end of the year, had followed Weddell's track in the antarctic seas until they were stopped by the ice between the 63d and 64th parallels. On three occasions an entrance was forced into it, but they were driven back each time, and forced to return. Louis-Philippe's Land, however, was discovered, and some positions of the shores beyond Brandsfield Straits determined. After a lengthened cruise in Polynesia and the Indian Archipelago, D'Urville resolved to make another attempt to get to the south, and touched at Hobart Town in a distressed condition, having lost three officers and thirteen men by dysentery. He sailed January 1, 1840, his special aim being to approach or reach the magnetic or terrestrial pole. The terrestrial meridian from Hobart Town to the pole coincides in a remarkable degree with the magnetic meridian, and by steering on the former, D'Urville hoped to arrive at both the poles he was searching for by the same route. On the 21st he was surrounded by numerous ice islands, and saw a lofty line of coast covered with snow stretching from south-west to north-west, apparently without limit. With some difficulty a landing was effected, and possession taken in the name of France: it was called La Terre Adélie, after the wife of the discoverer. Two days afterwards, the vessels were separated by a terrific storm: they, however, weathered through, and met again on the 28th in an open sea towards the north, from whence they steered a south-westerly course to complete a series of magnetic observations—keeping a look-out for land in that direction. On this route a ship was seen, which afterwards proved to be the *Porpoise*, one of the American squadron: the vessels passed without communicating; and in February 1840, D'Urville returned to Hobart Town. The subsequent fate of this persevering navigator was truly melancholy: after having escaped all the dangers of a sailor's life during thirty years, he was burnt to death, with his wife and son, in the railway train between Paris and Versailles in 1842.

The United States' Exploring Expedition, the first that ever left that country for a scientific purpose, sailed in August 1838. It comprised two sloops of war, the *Vincennes* and *Peacock*, the brig *Porpoise*, a store-ship, and two tenders. With respect to researches in the antarctic seas, Lieutenant Wilkes, the commander, was instructed to follow, as others had previously done, Weddell's track, and afterwards to explore as far as Cook's *ne plus ultra*, neglecting no opportunity of pushing to the south as might be compatible with the safety of the vessels. The *Porpoise* and *Seagull* tender sailed from Orange Harbour, on the west of Terra del Fuego, in February 1839 for the first southern cruise, and explored in the vicinity of the South Shetlands. The *Peacock* and *Flying-Fish* followed, and penetrated as far as 70 degrees, when the approach of winter compelled their return. Off Cape Horn the *Seagull* separated from her consort, and was never afterwards heard of. The second cruise was made from Sydney with four of the ships: they sailed December 29, two days before D'Urville. Lieutenant Wilkes chose the meridian of Macquarie Island, designing, after a long stretch to the south, to turn westward, and beat round the circle to Enderby Land, and make a dash towards the pole whenever practicable. On the 16th January, in latitude 66 degrees, he landed on what was taken for an island, but which subsequent researches gave reason to suppose was a floating mass of ice. To make the exploration as effective as possible, the ships separated. They were, however, so ill adapted for navigation among ice, that although great exertions were used to widen the search, one after another they were compelled to abandon the enterprise, after having incurred extreme distress and danger. The *Vincennes* was the last to return: on the 30th January, Lieutenant Wilkes entered a bay, which he named Piner's Bay, in latitude 66° 45′, and designated the country as the antarctic continent. The accumulations of floating ice prevented his reaching the shore, and he was then unaware that this was the Adélie Land of D'Urville. The French admiral had landed there a week previously, and taken possession. The American squadron returned to the United States in June 1842.

The last and most memorable voyage to the south is that by Captain (now Sir James) Ross, whose labours in arctic research will be well remembered. Its scientific results were highly important, and it settled the question of a *terra australis:* such a land may now find a place in maps: the dreams of theorists are verified. This voyage more immediately originated in a recommendation by the British Association in 1838, a period when the desirability of establishing the phenomena of terrestrial magnetism was strongly felt. Observatories were to be erected in different latitudes and in different zones of the earth, and much importance was attached to the filling up of the deficiencies of our knowledge of terrestrial magnetism 'in the high southern latitudes between the meridians of New Holland and Cape Horn.' The laws which regulated the movement of the needle were supposed to be extremely simple, operating in cycles, dependent on climatic or other and unknown causes. The simplicity, however, was apparent only: on investigation, the effects proved to be most complex, and the causes altogether unapproachable. Formerly, the variation alone was the phenomenon which received attention; now the dip and intensity were to be taken account of; and this, by a little contrivance, could be done at sea almost as well as on land. The inconstant nature of the phenomena had also to be considered, their relations to each other, their times and changes, and other incidents—all were essential in researches into the cause and effect of magnetism.

According to the report, so little was known of the magnetic lines of direction in the antarctic seas, 'that the true position of the south magnetic pole could scarcely even be conjectured from the data already known;' and it would be of high importance to determine whether the magnetic phenomena observed during the voyage were simultaneous with similar phenomena in Europe or other parts of the world. On these points Sir James Ross's instructions were express and explicit: he was to notice in the South Atlantic the point where he crossed the curve or line of least magnetic intensity; to ascertain the depth of the ocean whenever practicable, and the temperature and specific gravity of the water at different distances below the surface; the strength and direction of currents and tides; periodical movement of the barometer; comparative brightness of stars; refraction, both terrestrial and celestial; and to swing pendulums in special localities, whereby to prove the figure of the earth. After refitting at Van Diemen's Land, he was to 'proceed direct to the southward, in order to determine the position of the magnetic pole, and even to attain to it if possible, which it is hoped will be one of the remarkable and creditable results of this expedition,' one calculated to 'engross the attention of the scientific men of all Europe.'

It may perhaps assist towards a just appreciation of the results of this comprehensive voyage, to state briefly the three peculiarities of magnetic phenomena. There is within the polar circle of each hemisphere a point at which the dipping-needle points straight downwards—this is the *magnetic pole.* Midway between these two points, a line or curve may be traced all round the globe, on which the dipping-needle remains perfectly horizontal; this, through the greater part of its course, varies but slightly from a great circle whose plane is inclined about 12 degrees from the terrestrial equator; and, by analogy, it has been called the magnetic equator. Then, as is commonly known, the compass-needle takes a direction in different latitudes at times more or less oblique to the geographical meridian. The vertical plane hereby produced is called the magnetic meridian, and the angle which it forms with the terrestrial meridian on any part of the earth is termed the declination or variation of the needle. The amount is not constant in all seasons for the same place; and in the course of a single day, slight periodical changes occur, dependent apparently on the sun's height above the horison. But the absolute changes take place more slowly, at intervals of years; and navigators generally follow the compass, as though the local declination were always the same, correcting it, however, occasionally by astronomical observation. By this following of the compass the lines might be laid down: near the magnetic equator they are almost parallel or perpendicular to it, but departing from it, they assume a progressive contour or flexion, all finally converging and terminating in the two points where the dipping-needle becomes vertical. The third element of magnetic force is the law of its intensity at different places; this is indicated by oscillations, more or less rapid, of the respective needles, as measures of density are judged of by vibrations of a pendulum. Experience teaches that the intensity increases generally from the equator to the poles; but the progress of the increase, whether of dip or variation, is not regular—inequalities appear; effects have been noted in some localities which have not been witnessed in others. From this fact, the existence of a principal magnetic force attaching as a result to the whole mass of the globe has been inferred, whose general effects are modified locally by secondary magnetic forces, having their centres of action distributed at slight depths below the surface of the earth, in portions or districts probably affected by perturbations of the interior equilibrium.

Two vessels were fitted out, the *Erebus* of 350 tons, and the *Terror;* the latter having been repaired after returning from Back's hazardous voyage towards Repulse Bay. Ross and Crozier were the commanders, with sixty-four persons in each ship. They left Chatham on the 16th September 1839, and on the 5th of October were off the Lizard, the last point of England which they were to see for several years. 'It is not easy,' says Sir J. Ross, 'to describe the joy and light-heartedness we all felt as we passed the entrance of the Channel, bounding before a favourable breeze over the blue waves of the ocean, fairly embarked in the enterprise we had all so long desired to commence.' Scientific labours were immediately organized and carried out: the measured height of waves in the Bay of Biscay was 36 feet; at Madeira the height of the mountain was determined; magnetic observations were taken, and repeated afterwards at the Cape de Verds. On November 20, 'the hourly register of the height of the barometer, and the temperature of the air and surface of the ocean, was substituted for the three-hourly observations hitherto recorded, chiefly for the purpose of marking the progress of barometric depression in approaching, and reascension in receding from, the equator; a phenomenon represented as being of the greatest and most universal influence, as it is, in fact, no other than a direct measure of the moving force by which the great currents of the trade-winds are produced; so that the measure of its amount, and the laws of its geographical distribution, lie at the root of the theory of these winds.'

In the course of the following month another interesting fact was observed—the line of no dip. 'We had watched,' writes the captain, 'the progressive diminution of the dip of the needle; and steering a course as nearly south as the wind permitted, in order to cross the line of no dip at right angles, we found the change so rapid, as to be ascertained with great precision; so much so, that the signal for our being on the exact point of no dip, where the needles, being equally poised between the northern and southern magnetic systems, assumed a perfectly horizontal position, was being hoisted from both ships at the same instant of time. Nothing could be more satisfactory than the perfect accordance of our observations in a determination of so much importance: nor could it fail to be of more than ordinary interest to me to witness the needle thus affected; having some years previously, when at the north magnetic pole, seen it in a directly *vertical* position: nor was it unnatural, when we saw the south pole of the needle beginning to point below the horison, to indulge the hope that ere long we might be permitted again to see it in a similar position at the south magnetic pole of the earth.' Shortly afterwards, the curve of least magnetic intensity was crossed: this point is found on each meridian of the earth; in sailing from the equator towards each pole, there is a point where the influence, having gradually increased from *nil*, becomes most perceptible—these points form a curve round the world, and being variable, their exact determination becomes of much importance to science.

After touching at the Cape, and landing a party with materials and instruments for the establishment of a magnetic observatory, as had previously been done at St Helena, the ships proceeded to Kerguelen's Island, in approaching which they encountered the tempestuous weather so characteristic of high southerly latitudes. They remained here until the 20th July, pursuing diligently their magnetical, meteorological, geological, botanical, and other researches. Abundance of coal was found, a fact which in these days of ocean steam navigation may perhaps be turned to good account. The plants are much less numerous than in higher latitudes in the north: Parry met with sixty-seven species at Melville Island, and forty-five have been discovered at Spitzbergen, while Kerguelen Island produces but eighteen. Among these there is one which deserves especial mention—the Kerguelen cabbage, first noticed during Cook's stay at the island. Captain Ross remarks—'To a crew long confined to salt provisions, or indeed to human beings under any circumstances, this is a most important vegetable, for it possesses all the essentially good qualities of its English namesake, while, from its containing a great abundance of essential oil, it never produces heartburn, or any of those disagreeable sensations which our pot-herbs are apt to do. It abounds near the sea, and ascends the hills to their summits. The leaves form heads of the size of a good cabbage lettuce, generally terminating an ascending or prostrate stalk, and the spike of flowers borne on a leafy stem, rises from below the head, and is often two feet high. The root tastes like horse-radish, and the young leaves or hearts resemble in flavour coarse mustard and cress. For 130 days our crews required no fresh vegetable but this, which was for nine weeks regularly served out with the salt beef or pork, during which time there was no sickness on board.'

Out of the sixty-eight days that the vessels lay in Christmas Harbour, forty-five were so windy, with such violent gusts, as frequently to blow them over on their beam-ends; and any of the party who happened to be on shore on such occasions were obliged to lie down, to avoid being blown into the sea; and rain or snow fell every day but three. Severe gales attended them on their way to Van Diemen's Land, where, at Hobart Town, a third party was landed with instruments for a magnetic observatory. While lying here, Sir J. Ross heard of the French and American exploring expeditions, both of which had made discoveries to the south as far as 67 degrees of latitude; and to avoid entering on the scene of his labours by the same track, he departed from his original intention, and chose the meridian of 170 degrees east, being that on which Balleny had sailed up to 69 degrees.

On November 12, 1840, the summer season of that side of the world, the vessels, having been fully refitted, were found to be more efficient than when they left England, and the party sailed in search of new lands in unknown seas. They touched at the Auckland Islands, and remained until December 17, occupied with magnetic observations. On leaving this anchorage, every heart beat high with proud expectations of future success, for now the real voyage was begun. Christmas-day, which, though only four days after the midsummer day of those latitudes, was cold, wet, and snowy: it was, however, celebrated in the old English style. On the 27th the first icebergs were seen, in latitude 63° 20′ south. 'Unlike the icebergs of the arctic seas, they presented very little variety of form, but were generally of large size, and very solid appearance; bounded by perpendicular cliffs on all sides, their tabular summits varied from 120 to 180 feet in height, and several of them more than two miles in circumference.' Three days afterwards, they crossed the track of the Russian navigator Bellinghausen, in latitude 64° 38′ south, longitude 173° 10′ east: soundings taken here gave a depth of 1560 fathoms. The 1st of January 1841 found them on the outskirts of the pack or belt of ice which more or less densely engirdles the antarctic regions, as though nature here interposed

——— 'the storm rampant of her sanctuary:
The insuperable boundary, raised to guard
Her mysteries from the eye of man profane.'

The good cheer of New-Year's Day was not forgotten, and a suit of warm clothing was served out gratis to every one of the crews. On the 5th they beat into the main pack, and when fairly entered, found it lighter and more open than it appeared from the outside. Penguins, albatrosses, petrels, and seals, crowded about the vessels, and followed them in their winding course among the hummocks and floes. They got through the pack, which was here 200 miles wide, in four days; and on the 10th—one of those singular phenomena peculiar to the frozen latitudes—'not a particle of ice could be seen in any direction from the mast-head.' The dip was 85 degrees, an amount which marked their proximity to the magnetic pole, to which the ships were now directly steered. But on the next morning land, with lofty mountains, was seen a-head: one of these, 10,000 feet high, was named Mount Sabine; and later in the same day the latitude was found to be 71° 15′, the highest point reached by Cook in 1774. 'It was,' observes Ross, 'a beautifully clear evening, and we had a most enchanting view of the two magnificent ranges of mountains, whose lofty peaks, perfectly covered with eternal snow, rose to elevations varying from seven to ten thousand feet above the level of the ocean. The glaciers that filled their intervening valleys, and which descended from near the mountain summits, projected in many places several miles into the sea, and terminated in lofty perpendicular cliffs. In a few places the rocks broke through their icy covering, by which alone we could be assured that land formed the nucleus of this, to appearance, enormous iceberg.' It need hardly be said that the various heights and headlands within view were duly named after eminent individuals in England.

On the 12th, advantage was taken of fine weather to effect a landing: when about three miles from the shore, a boat put off from each ship with the captains and several of the officers. 'We found,' says Sir J. Ross, 'the shores of the mainland completely covered with ice projecting into the sea, and the heavy surf along its edge forbade any attempt to land upon it; a strong tide carried us rapidly along between this ice-bound coast and the islands amongst heavy masses of ice, so that our situation was for some time most critical; for all the exertions our people could use were insufficient to stem the tide. But taking advantage of a narrow opening that appeared in the ice, the boats were pushed through it, and we got into an eddy under the lee of the largest of the islands, and landed on a beach of large loose stones and stranded masses of ice. The weather had now put on a most threatening appearance, the breeze was freshening fast, and the anxious circumstances under which we were placed, together with the recall flag flying at the ship's mast-head, which I had ordered Lieutenant Bird to hoist if necessary, compelled us to hasten our operations.

'The ceremony of taking possession of these newly-discovered lands in the name of our most gracious sovereign Queen Victoria was immediately proceeded with; and on planting the flag of our country amidst the hearty cheers of our party, we drank to the health, long life, and happiness of her Majesty and his Royal Highness Prince Albert. The island was named Possession Island. It is situated in latitude 71° 56′ and longitude 171° 7′ east, composed entirely of igneous rocks, and only accessible on its western side. We saw not the smallest appearance of vegetation, but inconceivable myriads of penguins completely and densely covered the whole surface of the island, along the ledges of the precipices, and even to the summits of the hills, attacking us vigorously as we waded through their ranks, and pecking at us with their sharp beaks, disputing possession: which, together with their loud coarse notes, and the insupportable stench from the deep bed of guano, which had been forming for ages, and which may at some period be valuable to the agriculturists of our Australian colonies, made us glad to get away again, after having loaded our boats with geological specimens and penguins. . . . . After a long and heavy pull, we regained our ships only so short a time before so thick a fog came on, with a strong northerly breeze, that to have been a few minutes later would have rendered our return to the ships impossible.'

A heavy gale came on, but in the rolling sea which it produced, indications were gained of a large space of open water to windward, in the direction most desired by the explorers. While beating about, to prevent losing ground, other portions of land were seen; and on the 17th, when the weather cleared, mountain ranges were discovered at a distance of 100 miles, so great is the refractive power of the atmosphere in icy regions. On the 21st, the dip was 87° 39′, denoting a considerable approach towards the magnetic pole; and some vexation was felt that the barrier of land ice stood in the way of a direct course to the interesting spot; the alternative was, to beat up and seek a westerly route. On one occasion, while thus engaged, 'it was,' to quote the narrative, 'the most beautiful night we had seen in these latitudes, the sky perfectly clear and serene. At midnight, when the sun was skimming along the southern horison at an altitude of about 2 degrees, the sky overhead was remarked to be of a most intense indigo blue, becoming paler in proportion to the distance from the zenith.' The 22d was a notable day: the ships were in latitude 74° 20′, higher than had ever been reached by any former navigator; an event which naturally called forth much rejoicing. The dip had increased to 88° 10′ on the 25th, leaving the presumption that the pole was not more than about 200 miles distant. Two days later, formal possession was again taken of an island, to which the name of Franklin Island was given, in latitude 76° 8′ south, longitude 168° 12′ east. It is about twelve miles long and six broad, devoid of all appearance of vegetation; even the hardy mosses and lichens were absent, from which, and other instances, Sir J. Ross considers 'that the vegetable kingdom has no representative in antarctic lands.' It is the very sublimity of barrenness; and who, on reading the description, will not recall the lines—

> 'But here—above, around, below,
>   On mountain or in glen,
> Nor tree, nor shrub, nor plant, nor flower,
> Nor aught of vegetative power,
>   The weary eye may ken.
> For all is rocks at random thrown,
> Black waves, bare crags, and banks of stone,
>   As if were here denied
> The summer sun, the spring's sweet dew,
> That clothe with many a varied hue
>   The bleakest mountain-side?'

Early on the 28th the vessels stood towards the high land seen the day before: 'it proved to be a mountain 12,400 feet of elevation above the level of the sea, emitting flame and smoke in great profusion; at first the smoke appeared like snow-drift, but as we drew nearer, its true character became manifest.

'The discovery of an active volcano in so high a southern latitude cannot but be esteemed a circumstance of high geological importance and interest, and contribute to throw some further light on the physical construction of our globe. I named it Mount Erebus; and an extinct volcano to the eastward, little inferior in height, being by measurement 10,900 feet high, was named Mount Terror.'

Later in the same day the latitude was found to be 76° 6′, and the vessels were to the southward of the magnetic pole, the approach to which was impeded by land ice. Standing in for the land under all sail, 'we perceived a low white line extending from its eastern extreme point as far as the eye could discern to the eastward. It presented an extraordinary appearance, gradually increasing in height as we got nearer to it, and proving at length to be a perpendicular cliff of ice, between 150 and 200 feet above the level of the sea, perfectly flat and level at the top, and without any fissures or promontories on its even seaward face.' Far in the rear a range of mountains was seen, which were named the Parry Mountains, in honour of the eminent arctic explorer. They are the most southerly land as yet known on the globe. The sight of this barrier was a great disappointment to all on board, for they had anticipated being able to push their researches far beyond the 80th degree; but, as Sir J. Ross observes, they 'might, with equal chance of success, try to sail through the cliffs of Dover as penetrate such a mass.' They coasted along this icy wall to the eastward; and on the 2d February had increased the latitude to 78° 4′, the highest point ever reached; on the 9th they stood closer in, to a bay where the cliff being low, enabled them to look down upon it from the mast-head. 'It appeared to be quite smooth, and conveyed to the mind the idea of an immense plain of frosted silver: gigantic icicles depended from every projecting point of its perpendicular face.' Although in a season answering to the month of August in England, the temperature was not higher than 12 degrees, and did not rise above 14 degrees at noon; and so much young ice was formed during the nights, as to threaten a sudden stoppage to the exploration, which, however, was continued until the 13th, in hopes of coming to the end of the icy barrier, or to find some passage through it to the southward. But these expectations were not to be realised. After sailing along the frozen cliff for 450 miles, the vessels bore up to the westward, to make another attempt to reach the magnetic pole before the season finally closed. Unlike the bergs of the northern regions, which are dismembered by the action of the sea, 'this extraordinary barrier, of probably more than 1000 feet in thickness, crushes the undulations of the waves, and disregards their violence: it is a mighty and wonderful object, far beyond anything we could have thought or conceived.'

By the 17th it became apparent that the endeavour was useless: a secure harbour was then sought for, in which the vessels might winter, and from which parties could be sent overland in the spring to visit the burning mountain, whose frequent eruptions afforded a magnificent spectacle, and to discover the great centre of magnetic attraction. But after a hard struggle to reach an island through sixteen miles of intervening land ice, this attempt was also abandoned, not without much regret on the part of the commander, who had indulged the hope of planting the British flag on the southern magnetic pole as he formerly had on the northern. Still there was much satisfaction in knowing that they had penetrated farther towards the south than any other explorers, however adventurous, and that they had traced the coast of a great unknown continent from the 70th to the 79th degree of latitude. They were then in latitude 76° 12′ south, longitude 164° east, the dip 88° 40′, and 'were therefore only 160 miles from the [magnetic] pole.'

On the 25th, as Ross relates, 'we had a good view of the coast. The whole of the land being perfectly free from cloud or haze, the lofty range of mountains appeared projected upon the clear sky beyond them beautifully defined; and although of a spotless white, without the smallest patch of exposed rock throughout its whole extent to relieve it, yet the irregularities of the surface, the numerous conical protuberances and inferior eminences, and the deeply-marked valleys, occasioned many varieties of light and shade, that destroyed the monotonous glare of a perfectly white surface, but to which it is so very difficult to give expression either by the pencil or description. It was a most interesting scene to us, as it was truly the best view we had of the northern shore and mountains of Victoria Land, and of which the western extremity was by no means the least remarkable feature.'

The nights were lengthening; stars became visible; everything betokened the rapid approach of winter. Ross, however, determined on ascertaining whether any connection existed between the new-found continent and the

Balleny Isles, and bore up for this purpose. On the evening of the 28th the party had their last sight of Victoria Land, and the first of the aurora australis, which differs from the northern lights 'in the greater length of the vertical beams, and the frequency and suddenness of its appearances and disappearances—more like flashes of light: it was again also perfectly colourless, had considerable lateral flitting motion, and formed an irregular arch about 30 degrees high, whose centre bore west.'

On the 2d March land was seen which had the appearance of two islands; if not part of the group discovered by Balleny in 1839, it was considered they might eventually prove to be mountains. Here Sir J. Ross takes some pains to distinguish between the English, French, and American explorations, and to show the propriety of not laying down a chain of islands as the coast of a continent. He believes that the priority of discovery between the meridians of 47 degrees and 163 degrees of east longitude belongs to the English. On the 4th March the ships recrossed the antarctic circle, having been to the southward of it for sixty-three days; and until the 7th the party were searching for the land which Lieutenant Wilkes thought he had discovered; but soundings were taken in 600 fathoms, in the very centre of the position assigned to the land on the chart, and Ross is of opinion that the American commander was deceived by ice-islands or fog-banks. On the last-mentioned day they were for several hours in a position of extreme danger: it fell calm, and under the dead set of the waves the ships were slowly drifted down to a range of huge icebergs, against which the sea broke with appalling violence. Every eye was transfixed with the tremendous spectacle, and destruction appeared inevitable: thus were they driven for eight hours, until within half a mile of the bergs, when a gentle air stirred, the heavy ships yielded slowly to its influence; it freshened to a breeze, and before dark, to the heartfelt thankfulness of all, they were far from danger. On the 6th April they anchored once more at Hobart Town, all hands well, after an absence of five months.

In July of the same year, 1841, the ships sailed again for a second voyage to the southward: after touching at New Zealand, they took an easterly course, and having thereby gained twelve hours, it became necessary, on crossing the 180th degree, and entering on west longitude, to lose a day, so as to make the date correspond with that in England. 'We had, therefore,' says Captain Ross, 'two Thursdays and two 25th days of November in succession; so that, after crossing the meridian, and having made the alteration of a day, instead of being twelve hours in advance, we became so much in arrear of the time in England, which would gradually diminish as we pursued our easterly course, until on our return we should find them in exact accordance.' On the 4th December, soundings were taken in 1050 fathoms; the temperature of the water at that depth was 40 degrees—thirteen degrees lower than at the surface. A current was found setting to the south-east at the rate of fifteen miles a day; a similar stream had been noticed at Kerguelen Island, and there is reason to believe that it circulates continually round the Antarctic Ocean in a stream about 10 degrees wide on either side of the fiftieth parallel of latitude. A few days afterwards a thick fog afforded an opportunity of testing the relative value of sound-signals, and the effects were as extraordinary as those observed in the north. 'The bell was most distinct, and the gong very little inferior, when the musket was scarcely audible; but I was much surprised,' remarks the captain, 'on hailing through a speaking-trumpet, to receive an immediate and so clear an answer from the officer of the watch of the *Terror*, that we might have carried on a conversation.' On the 16th, having reached the meridian of 146° 43′ west, the ships' heads were directed to the south, this being the most favourable line for observations on the magnetic intensity, and the one on which land was most likely to be met with. Having passed the outskirts of the pack, the main body was entered on the 19th, through which their progress was slow and toilsome; the party, however, managed to spend Christmas-day cheerfully, notwithstanding their imprisonment. Sometimes they were obliged to moor the vessels on either side of a large floe, and drift with it, to prevent collision. 'It seldom happened that a piece exceeding a quarter of a mile in circumference was met with, thus presenting a striking difference of character in the pack of the Antarctic from that of the Arctic Sea, where floes of several miles in diameter are of common occurrence, and sometimes "fields," as they are termed, whose boundary is beyond the reach of vision from a ship's masthead. The cause of this is explained by the circumstance of the ice of the southern regions being so much more exposed to violent agitations of the ocean, whereas the northern sea is one of comparative tranquillity.'

The antarctic circle was crossed on the 1st day of 1842, the anniversary of the crossing on the former voyage, but 1400 miles more to the west. Here the ice was met with in a lower latitude, and during several days ground was lost by a current drifting the ships to the northwards. While beset, the crews were frequently employed in catching seals, or collecting such specimens of natural history as came in their way, many of which are now to be seen in the British Museum. What the land lacks in vegetable life, is made up by the teeming and varied animal life in the ocean; from the minute infusoria, in inconceivable myriads, up to the huge whale and sea-elephant, multitudinous gradations exist, the grand circle of existence ever maintained by the lesser serving as food for the larger. The penguins were found extremely difficult to kill when required to be preserved unmutilated; at last prussic acid was resorted to, and a table-spoonful of this destroyed them in less than a minute. Thus it continued until the 19th, alternately hunting, drifting, hauling, making fast, hawsers snapping, and efforts to stem the opposing current. On this day, while the ships were endeavouring to keep company by signals during a thick fog, a gale came on from the north: 'the sea,' as Sir J. Ross describes, 'quickly rising to a fearful height, breaking over the loftiest bergs, we were unable any longer to hold our ground, but were driven into the heavy pack under our lee. Soon after midnight, our ships were involved in an ocean of rolling fragments of ice, hard as floating rocks of granite, which were dashed against them by the waves with so much violence, that their masts quivered as if they would fall at every successive blow; and the destruction of the ships seemed inevitable from the tremendous shocks they received. By backing and filling the sails, we endeavoured to avoid collision with the larger masses; but this was not always possible. In the early part of the storm the rudder of the *Erebus* was so much damaged as to be no longer of any use; and about the same time I was informed by signal that the *Terror's* was completely destroyed, and nearly torn away from the stern-post. We had hoped that, as we drifted deeper into the pack, we should get beyond the reach of the tempest; but in this we were mistaken. Hour passed away after hour without the least mitigation of the awful circumstances in which we were placed. Indeed there seemed to be but little probability of our ships holding together much longer, so frequent and violent were the shocks they sustained. The loud crashing noise of the straining and working of the timbers and decks, as she was driven against some of the heavier pieces, which all the activity and exertions of our people could not prevent, was sufficient to fill the stoutest heart—that was not supported by trust in Him who controls all events—with dismay; and I should commit an act of injustice to my companions if I did not express my admiration of their conduct on this trying occasion, throughout a period of twenty-eight hours, during any one of which there appeared to be very little hope that we should live to see another: the coolness, steady obedience, and untiring exertions of each individual were every way worthy of British seamen.

'The storm reached its height at two P.M., when the barometer stood at 28·40 inches, and after that time began to rise. Although we had been forced many miles deeper into the pack, we could not perceive that the swell had at all subsided, our ships still rolling and groaning amidst the heavy fragments of crushing bergs, over which the ocean rolled its mountainous waves, throwing huge masses one upon another, and then again burying them deep beneath its foaming waters, dashing and grinding them together with fearful violence. The awful grandeur of such a scene can neither be imagined nor described, far less can the feelings of those who witnessed it be understood. Each of us secured our hold, waiting the issue with resignation to the will of Him who alone could preserve us, and bring us safely through this extreme danger; watching with breathless anxiety the effect of each succeeding collision, and the vibrations of the tottering masts, expecting every moment to see them give way without our having the power to make an effort to save them.

'Although the force of the wind had somewhat abated by four P.M., yet the squalls came on with unabated violence, laying the ship over on her broadside, and threatening to blow the storm-sails to pieces: fortunately they were quite new, or they never could have withstood such terrific gusts. At this time the *Terror* was so close to us, that when she rose to the top of one wave, the *Erebus* was on the top of that next to leeward of her; the deep chasm between them filled with heavy-rolling masses; and as the ships descended into the hollow between the waves, the main-top-sail-yard of each could be seen just level with the crest of the intervening wave from the deck of the other. From this some idea may be formed of the height of the waves, as well as of the perilous situation of the ships. The night now began to draw in, and cast its gloomy mantle over the appalling scene, rendering our condition, if possible, more hopeless and helpless than before; but at midnight the snow, which had been falling thickly for several hours, cleared away as the wind suddenly shifted to the westward, and the swell began to subside; and although the shocks our ships still sustained were such that must have destroyed any ordinary vessel in less than five minutes, yet they were feeble compared with those to which we had been exposed, and our minds became more at ease for their ultimate safety.'

On the morning of the 21st Captain Ross was enabled to visit the *Terror* in a boat. He found the rudder broken to pieces, and other damage; yet so well fortified were the vessels, and their holds so well stowed, that the bottoms remained sound. During the calm which followed, the rudders were hoisted on board, and carpenters and armourers worked busily at their repair: a new one was made for the *Terror*. While waiting for the ice to open, the latitude was taken, 66° 39′, the same which they had passed three weeks before, in addition to which the five best weeks of the season had been lost by fighting through the pack. By the 24th both rudders were hung and secured; and still moored to a floe, the vessels drifted before the wind slowly to the southward. They were not far from the spot where Cook had found a clear sea, so different is the situation of the pack in different years. At length, on February 2d, after a struggle of fifty-six days, they cleared the ice, the pack where they crossed it being 1000 miles wide. Passing the outer barrier through a line of threatening breakers was not accomplished without much difficulty, and, to the great joy of all on board, the vessels were once more in open water. On the 20th, although not more than thirty miles to east of the point from which they turned back in the former year, no ice was visible; but the wind blowing from the south over the accumulated ice in that direction was piercing cold—so much so, that a small fish washed against the ice accumulated on the *Terror's* bow was at once frozen fast. On the 23d they were off the great icy barrier in latitude 78° 9′ 30″ south, longitude 161° 27′ west; and from its being comparatively low, they hoped to get round its eastern end, but soon saw it trending to the northwards. Young ice now formed so rapidly, that they were obliged to retreat, the result of this voyage being the attainment of a somewhat higher latitude than in the previous year, and an examination of the barrier 10 degrees more to the east. The vessels recrossed the antarctic circle on March 6th, after passing sixty-four days within it, and bore up for the Falkland Islands. A week later, when all further danger from the ice was considered to be at an end, a chain of bergs was seen, and preparations were made to lie to. 'Just at this moment,' writes Sir J. Ross, 'the *Terror* was observed running down upon us, under her topsails and foresail; and as it was impossible for her to clear both the berg and the *Erebus*, collision was inevitable. We instantly hove all aback to diminish the violence of the shock; but the concussion, when she struck us, was such as to throw almost every one off his feet: our bowsprit, fore-topmast, and other smaller spars, were carried away; and the ships hanging together, entangled by their rigging, and dashing against each other with fearful violence, were falling down upon the weather-face of the lofty berg under our lee, against which the waves were breaking and foaming to near the summit of its perpendicular cliffs. Sometimes the *Terror* rose high above us, almost exposing her keel to view, and again descended as we in our turn rose to the top of the wave, threatening to bury her beneath us; whilst the crashing of the breaking upper works and boats increased the horror of the scene. Providentially the vessels gradually forged past each other, and separated before we drifted down among the foaming breakers; and we had the gratification of seeing our consort clear the end of the berg, and of feeling that she was safe. But she left us completely disabled: the wreck of the spars so encumbered the lower yards, that we were unable to make sail so as to get headway on the ship; nor had we room to wear round, being by this time so close to the berg, that the waves, when they struck against it, threw back their sprays into the ship. The only way left to us to extricate ourselves from this awful and appalling situation, was by resorting to the hazardous expedient of a stern board, which nothing could justify during such a gale, and with so high a sea running, but to avert the danger which every moment threatened us of being dashed to pieces. The heavy rolling of the vessel, and the probability of the masts giving way each time the lower yard-arms struck against the cliffs, which were towering high above our mast-heads, rendered it a service of extreme danger to loose the mainsail; but no sooner was the order given, than the daring spirit of the British seaman manifested itself—the men ran up the rigging with as much alacrity as on any ordinary occasion; and although more than once driven off the yard, they, after a short time, succeeded in loosing the sail. Amidst the roar of the wind and sea, it was difficult both to hear and to execute the orders that were given, so that it was three-quarters of an hour before we could get the yards braced by, and the maintack hauled on board sharp aback—an expedient that perhaps had never before been resorted to by seamen in such weather: but it had the desired effect: the ship gathered sternway, plunging her stern into the sea, washing away the gig and quarter-boats, and with her lower yard-arms scraping the rugged face of the berg, we in a few minutes reached its western termination; the "undertow," as it is called, or the reaction of the water from the vertical cliffs alone preventing us being driven to atoms against it. No sooner had we cleared it, than another was seen directly astern of us, against which we were running; and the difficulty now was to get the ship's head turned round, and pointed fairly through the two bergs, the breadth of the intervening space not exceeding three times her own breadth. This, however, we happily accomplished; and in a few minutes after getting before the wind, she dashed through the narrow channel, between two perpendicular walls of ice, and the foaming breakers which stretched across it, and the next moment we were in smooth water under its lee.'

One of the objects of this cruise was to visit, if possible, the focus of greater magnetic intensity as laid down in theory: the spot was reached on the 18th March, in latitude 60° south, longitude 125° west; and from the observations then taken, Sir J. Ross inclines to the belief that it will be found in a position not far removed from the south magnetic pole. After this interesting operation, the vessels bore up for Cape Horn, running more than 150 miles daily before the strong westerly gales. They were off the Diego Ramirez rocks, when one of the quartermasters fell from the mainyard into the sea. 'The life-buoy being instantly let go, he swam to and got upon it with apparent ease, so that,' to pursue the narrative, 'we now considered him safe. Although there was too high a sea running for any boat to live, yet Mr Oakley and Mr Abernethy, with their accustomed boldness and humanity, were in one of the cutters ready to make the attempt. I was obliged to order them out of the boat, for the sea was at this time breaking over the ship in such a manner as to make it evident that the cutter would have instantly filled, whilst, by making a short tack, we could fetch to windward of the buoy, and pick him up without any difficulty. We therefore made all sail on the ship, and stood towards him: but just as we got within 200 yards, the wind headed, and obliged us to pass to leeward, so near, however, as to assure us of being able to fetch well to windward after a short board. He was seated firmly on the buoy, with his arm round the pole, but had not lashed himself to it with the cords provided for that purpose, probably from being stunned or stupified by striking against the ship's side as he fell overboard. In a quarter of an hour we again stood towards him, with the buoy broad upon our lee-bow; but, to our inexpressible grief, our unfortunate shipmate had disappeared from it. We dropped down upon it so exactly, that we could take hold of it with a boat-hook; and had he been able to have held on four or five minutes longer than he did, his life would have been saved—but it pleased God to order it otherwise.'

The gloom produced by this melancholy event was somewhat dissipated on the following day by the sight of a brig, the only vessel except their own which the explorers had seen for four months. Those alone who have passed long weeks on the ocean solitudes can appreciate the pleasurable feeling which even a distant view of the presence of humanity inspires. While in this latitude, several sealed bottles were thrown overboard, to ascertain the set of the current in the vicinity of Cape Horn; one of them was afterwards picked up near Port Philip, Australia, in September 1845, on which it has been observed 'that the motion of the bottle must have been eastward; and assuming that it had newly reached the strand when discovered, it had passed from the vicinity of Cape Horn to Port Philip, a distance of 9000 miles, in three years and a-half. But it could not be supposed that its course was exactly straight; and if we add a thousand miles for *détours*, it follows that the current which carried it moved at the rate of eight miles per day.' Some of the bottles were ballasted with different quantities of sand, so as to ascertain as nearly as possible the effect of current as well as of wind: those which swam deepest it was supposed would be the truest indicators of streams.

The vessels anchored in Berkeley Sound, Falkland Islands, on the 6th April, where active measures were at once taken for their effectual repair. Astronomical and magnetic observatories were erected on shore, and a regular system of readings taken; hunting-parties were sent out to kill wild cattle and birds, and all hands regaled for a time on fresh beef. They sailed again on September 4, for Martin's Cove, Hermite Island, to conduct a series of magnetic experiments. On the 19th Cape Horn was in sight, on which Sir J. Ross remarks—'The poetical descriptions that former navigators have given of this celebrated and dreaded promontory occasioned us to feel a degree of disappointment when we first saw it; for although it stands prominently forward, a bold, almost perpendicular headland, in whose outline it requires but little imaginative power to detect the resemblance of a "sleeping lion, facing and braving the southern tempests," yet it is part only of a small island; and its elevation, not exceeding 500 or 600 feet, conveys to the mind nothing of grandeur. But the day was beautifully fine, so that it is probable we saw this cape of terror and tempests under some disadvantage. We passed it at the distance of about a mile and a-half, which was as near as we could approach it with prudence, by reason of the dangerous rocks which lie off to the east and west, and whose black points were rendered conspicuous by the white foam of the breakers, amongst which numerous seals were sporting. There was some snow on the summit of the cape, and its sides were clothed with a brownish-coloured vegetation; beyond it, the shores of the island consisted of black vertical cliffs.'

While lying in Martin's Cove, hundreds of young trees were collected, to be transplanted in Falkland Islands, which were totally devoid of arborescent vegetation. The ships left Berkeley Sound once more on the 17th December for the third voyage to the circumpolar latitudes, taking the meridian of 55 degrees west. On the 28th the land discovered by D'Urville was seen, and the party became entangled among a group of small low isles, called the Danger Islets, to the southernmost of which they gave the name of Darwin. 'We observed here,' says Ross, 'a very great number of the largest-sized black whales, so tame, that they allowed the ship sometimes almost to touch them before they would get out of the way—so that any number of ships might procure a cargo of oil in a short time. Thus within ten days after leaving the Falkland Islands we had discovered not only new land, but a valuable whale fishery, well worthy the attention of our enterprising merchants, less than 600 miles from one of our own possessions.' Several other islands were discovered, on one of which, named Cockburn Island, a landing was effected; it presented the usual volcanic appearance, but was interesting as affording specimens of the most southerly vegetation yet met with beyond the 60th degree of latitude. Nineteen species were found, consisting of mosses, lichens, and algæ—seven of them being peculiar to the island. Among the most remarkable was a magnificent sea-weed, which grows in long flat sheets bordered by a fringe. Singular as the fact may appear, sunshine is not congenial to the vegetation of that frozen land; the only soil is a stony bank composed of fallen fragments from the rocks above, in which the plants fix their roots and flourish during moist and cloudy weather; but as soon as the sun appears for a few hours, the scanty moisture is so speedily evaporated, that they 'become crisp and parched, and crumble into pieces when an attempt is made to remove them.'

For some days after this the ships were closely beset, and exposed to much danger from pressure between the ice and the land. The navigation proved of the most harassing nature: in latitude 65° 13′, where Weddell had seen a clear sea, they found a dense, impenetrable pack. The antarctic circle was crossed March 1, 1843, and the serious difficulties and delays the party had met with can be judged of from this fact; for it was within a day or two of this date that they had crossed it on returning from their two former voyages. On the 3d soundings were taken, and showed no bottom at 4000 fathoms; and two days later, when in latitude 71° 30′ south, longitude 14° 51′ west, no farther hope remaining of penetrating successfully to the southward so late in the season, the ships' heads were turned in the direction of the Cape of Good Hope, all parties disappointed at the result of the voyage, so fruitless in comparison with the two former. In September the vessels arrived at Woolwich, after having been in commission four years and five months.

The interesting physical facts and results brought to light by this voyage have added materially to the resources of science and philosophy. Among the more noteworthy is the discovery that the ocean which envelops our globe is divided into three thermal basins—two polar, one equatorial. The bottom is occupied by a fluid layer more or less deep, of one uniform temperature, 39·5. On the equator, and in the intertropical regions where the warmth of the sun penetrates sensibly, the temperature of 39·5 is not reached at a less depth than 1200 fathoms below the surface; on the parallel of 45 degrees it is found at half this depth; and at 56° 14′ it is the same above and below. Thus in the last-mentioned latitude a circular zone exists of constant and uniform temperature. Sir J. Ross crossed it six times in six different longitudes, and always with the same result—the approach to it was invariably indicated by the thermometer; and he considers it as a sort of neutral girdle between the two basins, and as establishing the fact of the actual mean temperature of the mass of water, unaffected by the interior heat of the earth. South of the line the surface becomes colder, and in latitude 70 degrees, a thermometer must be sunk 750 fathoms to reach the temperature of 39·5.

'This circle of mean temperature of the southern ocean,' as Sir J. Ross observes, 'is a standard point in nature, which, if determined with very great accuracy, would afford to philosophers of future ages the means of ascertaining if the globe we inhabit shall have undergone any change of temperature, and to what amount, during the interval.'

From this voyage we learn also that the pressure of the atmosphere at the level of the sea is not the same in every part of the globe. Barometrical observations show that this pressure increases gradually from the equator to about the 30th parallel, from which it as gradually sinks up to the pole, and falls below the mean of the equator: generally stated, we may say that, south of Cape Horn, the mercury stands an inch lower than in other regions. This difference of pressure is assigned as a mechanical cause of ocean currents, of which the most powerful issue from the south polar seas; or it may be that the greater quantity of fixed ice, or the greater expanse of water in those parts, admits of a more powerful generation and propagation of streams than in the north; and to this cause we may perhaps refer the presence of icebergs 10 degrees lower in the antarctic than in the arctic regions.

Our knowledge of climatic phenomena is also enlarged: Sandwich Land, in the same latitude as the north of Scotland, is always deeply buried in ice and snow, which the summer fails to melt; Yorkshire and South Georgia are about the same parallels, yet the only vegetation of the latter is a few lichens and mosses; while Iceland, which lies 10 degrees nearer to the northern pole, has 870 species of plants. Hermite Island is the most southerly land on which trees grow.

There is much similarity between the northern and southern elliptic magnetic curves, as also in their progression or 'movement of translation.' This movement in the antarctic regions is generally from east to west, and at the rate of 50 degrees of longitude in 250 years. In the arctic regions it is from west to east; the phenomenon in either case being discoverable by the shifting of the points of convergence. The same uniformity does not occur in the isothermals, or lines of equal heat: those in the south, owing doubtless to the greater extent of ocean, are more nearly coincident with the parallels of latitude than those in the north; the principal deviation being where the great polar current pours into the Pacific.

Complete as Sir J. Ross's voyage was, it did not satisfy the whole demands of magnetic theorists. The sea beyond the 60th parallel, from opposite the Cape of Good Hope to the southern extremity of Australia, had not been visited; and without this, the curves of magnetism could not be produced on the maps. In compliance with the desires expressed for the filling up of this space, the *Pagoda*, a merchant vessel, was selected at the Cape, and placed in charge of Lieutenant Moore, who had been out in the *Terror*, assisted by Lieutenant Clerk. They sailed January 9, 1845, and crossed the antarctic circle on the 8th February, and on the 10th reached their farthest latitude south, 68° 10′. Nothing occurred beyond the ordinary incidents of navigation among ice; the series of magnetic observations was faithfully registered; and on April 1, after being eighty-two days at sea, and a voyage of 7300 miles, the vessel anchored in King George's Sound, Australia. Some phenomena of antarctic storms which had been observed by Sir J. Ross were also observed on board the *Pagoda*. 'Nothing,' says the account of the voyage, 'in the meteorology of those inclement regions is more remarkable than the accurate coincidence of the depression of the barometer, and the increased force of the wind. The numerous, indeed hourly observations made on board the *Pagoda*, were expressed in tabular charts, in which this coincidence was beautifully exemplified. In the succession of gales we had encountered, it obtained so uniformly, that this instrument was confidently relied on as a certain indicator of the coming storm. A sudden, rapid fall preceded the rising of the wind; it was lowest just before the gale reached its utmost height, and rose again as it broke. Those storms, though of extreme violence, never exceeded twelve hours in duration, and invariably blew from the south or east. As they subsided, the column of mercury rose rapidly, and to a higher elevation than before.'

Such are the results of explorations carried on during a period of four centuries: the knowledge has been slowly gathered, but it will now remain a lasting testimony to the triumphs of intellect. Whether the new whale-fishery established at the Auckland Islands will lead to further discoveries beyond those already achieved, is a question for the future to determine. Human enterprise has learned many of the secrets of that region of mighty contrasts, and will doubtless, when opportunity offers, pursue the investigation. Meantime the wintry solitudes of the far south will be undisturbed by the presence of man; the penguin and the seal will still haunt the desolate shores; the shriek of the petrel and scream of the albatross will mingle with the dash and roar of continual storms and the crash of wave-beaten ice; the towering volcano will shoot aloft its columns of fire high into the gelid air; the hills of snow and ice will grow and spread; frost and flame will do their work, till, in the wondrous cycle of terrestrial change, the polar lands shall again share in the abundance and beauty which now overspread the sun-gladdened zones.

[No. 5.]

CHAMBERS'S

PAPERS FOR THE PEOPLE.

THE SANITARY MOVEMENT.

THE first half of the nineteenth century has been pre-eminently a period of contrasts — great and impressive, often startling, at times inexplicable. Twenty years of war have been followed by thirty years of peace, in which human capabilities have developed themselves to an unprecedented extent. England, in her plenitude of power, has surpassed the achievements of the mightiest of bygone nations. In her mastery over physical elements rude nature has been conquered; and art, science, and mechanical ingenuity have risen to a pitch of refinement which, but that we have grown up among the results, would appear as the exaggerations of untamed fancy. Whatever can contribute to pleasure, comfort, luxury, convenience, is infinitely multiplied and realised: we see it in halfpenny steamboats, penny postage, express and excursion trains, and the electric thought-flasher—all telling of energy and progress. And yet, side by side with all this wealth of power and enterprise we find elements of weakness, of degeneracy, of perdition even, which are not to be paralleled in countries the most barbarous, among people the most untutored.

Of all the great undertakings by which the era is signalised, there is perhaps none which so clearly stamps a character of real and essential progress as the Sanitary Movement; for the result of this, mediate and immediate, is a positive, a cumulative good; a social, moral, and—shall we add?—intellectual amelioration of a most beneficial nature—one which we believe destined to effect great results in the material advancement of a people. Its ultimate effect, whether so intended or not, lies beyond the pecuniary advantage—the pounds, shillings, and pence: it recognises the existence of claims and sympathies—intimate relations between all phases and grades of society. It matters not that those who held the might and controlled the capabilities had to learn their rudiments of duty and responsibility in a severe school; that their attention was compulsory rather than spontaneous; that motives of not exalted character were brought into play: it was something gained when the conviction was established, that it would be no longer safe or politic to ignore the existence of 'masses' of population, for the multitudes proved their kin from time to time by fatal evidence—in the communication of mortal disease. Distress and misery could not seize on the destitute ranks without foraying, so to speak, for victims among those in happier positions. And slowly and painfully the great truth forced itself into notice—that negligence and ignorance were costly as well as criminal; that 'classes' might be 'dangerous' in more senses than one; that interests involving other than temporal consequences were recklessly slighted, flung away as worthless.

It matters not, we repeat, in what way the impulse originated; the prime fact remains, that it was felt and obeyed, and inspired the inquiries—What are we to do? and, How are we to do? One obvious course was to try backward and trace effects to their causes; to discover why the groundwork of opulence, luxury, and health, should be indigence, misery, and appalling mortality. Here ever-increasing wealth; there ever-grinding poverty. Hope and ever-widening knowledge on the one hand; despair and foulest ignorance on the other. Extremes meet; and, as we have seen, lofty and lowly are brought together by grim compensations.

Were it necessary, we might go back to ages long anterior to our own historical period, and show that certain leading principles have been recognised and acted on by the wise as essential to health and vigour of body, which principles could not be departed from without risk or penalty. But such a survey is incompatible with our present scope; we need not even insist on Hippocrates or Galen; our purpose will be efficiently attained by taking the philosophy of Bacon as our retrospective limit, as the primary text. 'There is a wisdom,' writes the master, 'beyond the rules of physic: a man's own observation, what he finds good of, and what he finds hurt of, is the best physic to preserve health. Examine thy customs of diet, sleep, exercise, apparel, and the like, and try, in anything thou shalt judge hurtful, to discontinue it by little and little.' Add to this what he says on habitations, and we have the pith of the whole matter.

Although during the eighteenth century a few examples were given of the advantage of treating health on principle, it was reserved for the present generation, as already mentioned, to bring the vast accumulation of unconnected experiences to bear with comprehensive force on the whole question. The carrying out of the New Poor-Law may be regarded as the starting-point of the inquiries which led to the Sanitary Movement: medical men of enlightened minds were authorised to collect evidence on certain social phenomena said to favour pauperism; and this evidence, when logically collated, presented an amount of proof altogether irresistible. Still, the knowledge of the facts was confined to a very limited circle—of those especially interested either in the economical or the scientific bearing. The doctrine was broached that disease was not inevitable; that its physical causes were removable. Hence in 1839 the further inquiry authorised by government in England, Wales, and Scotland, which embraced the condition of the labouring population in towns and rural districts—their dwellings, relative to cost and comfort; wages and expenditure; and means of cleanliness and decency everywhere, whether public or private. With respect to dwellings, the assistant commissioners were instructed to 'inquire as to the comparative health and condition of the inmates, and whether the advantage of improved dwellings has been observed to have any salutary influence on the moral habits of the inmates; whether the increased comforts of his house and home have tended to withdraw the labourer from the beer-shop, and from the habits of improvidence to which it leads; whether residents in separate and improved tenements are superior in condition as compared with the labourers who hold merely lodgings, or who reside with other families in the same house.' Thus a moral object, the vital principle of the whole, was kept in view; and to this we owe whatever of good has as yet resulted from the science of sanitation.

An idea of the specific obnoxious influences may be formed from the queries addressed to medical practitioners, and others who assisted in the preliminary investigation. It had been remarked that certain localities in town and country were always infested by contagious febrile disease, and it was desirable to know 'Whether the surrounding lands are drained or undrained? Whether there is a proper supply of water for the purposes of cleanliness of the houses, persons, and clothing? Whether there are good means of ventilation with a due regard to warmth? Whether there are proper receptacles for filth in connection with the cottages? Whether such residences are unduly crowded, and several families or persons occupy the space which would properly suffice only for a less number? Whether there are any inferior lodging-houses crowded by mendicants or vagrants? Whether there is a gross want of cleanliness in the persons or habitations of certain classes of the poor? Whether there is a habit of keeping pigs, &c. in dwelling-houses, or close to doors or windows?' These are but a few out of the whole number, but they exhibit the general scheme. Out of the replies furnished on the several points, Mr Chadwick, in 1842, produced his valuable 'Report on the Sanitary Condition of the Labouring Population of Great Britain,' in which the whole mass of evidence for the first time was most ably discussed. This treatise, as it may be called, on sanitation and social economy, was followed in 1843 by a supplementary report 'On the Practice of Interment in Towns'—of burying the dead in the midst of the living, of which more by and by. The judicious spirit in which these two works are drawn up is such as will long preserve the reputation of their author among the most eminent of sanitary reformers. In June 1844 appeared the 'First Report of the Health of Towns' Commission on the State of Large Towns and Populous Districts.' The objects of the inquiry on which this report was based were generally the same as those quoted above; in fact all later evidence may be considered as an elaboration of that published by Mr Chadwick in 1842. The new investigations confirmed the former facts both in cause and effect. The sceptical could no longer claim the privilege of doubting that 'defective drainage, neglect of house and street cleansing, and ventilation, and imperfect supplies of water, contribute to produce atmospheric impurities which affect the general health and physical condition of the population, generating acute, chronic, and ultimately organic disease, especially scrofulous affections and consumption, in addition to fevers and other forms of disease.' In reply to the official series of sixty-two queries, returns were obtained from municipal and other public officers in fifty towns, including the large seats of manufactures, seaports, and 3,000,000 of the population; besides which, each town was visited by an authorised inspector for the proper verification of the facts. Defects in the law of sewers, instituted in the reign of Henry VIII., were pointed out, and amendments suggested. The chief and most obvious use of sewers had been strangely overlooked or disregarded. 'In some of the larger and most crowded towns,' observe the Commission, 'all entrance into the sewers by house-drains, or drains from water-closets or cesspools, is prohibited under a penalty. In other places, including a part of the metropolis, the entrance of house-drains is commonly deemed the concession of a privilege.' So if a man wished to take measures for the promotion of health in his household, he could only do so under favour! It further appeared, almost without exception, that in all structural arrangements there was no plan: every builder built as to him seemed best; and houses were 'run up' without the slightest regard to drainage, decency, or real comfort for the expected tenants. The statements might well stagger belief: although a few cheering facts stood out amid the overwhelming weight of discouragement; and wherever remedial measures had been applied, although isolated or imperfect, great good had followed. Here was sufficient ground for a recommendation of powers, while, to avoid the burthen and vexation of new and increased rates, the principle was suggested of 'spreading the expense of the outlay over an extended period, so that the cost might be repaid within a reasonable time, with interest, by an annual rate.' The evidence showed that an addition might be made to topographical nomenclature: if the provinces could boast of 'Montpeliers' and 'Vales of Health,' and towns of 'West-Ends' and stately 'Malls,' so could the one and the other lay claim to 'Fever districts'—and permanent ones, for in them fever was as persistent as in the pestilential swamps and jungles of the torrid zone. The aspect of towns, taking the metropolis as a type, was too much after the manner of social usages—a sham. The main thoroughfares, showy, spacious, passably clean, such as might be required by a highly-civilised community, which would impose on a casual visitor or incurious citizen, but which only served to mask a 'behind the scenes' of quite another character. The long tall rows of houses concealed deformities worse than hideous, with here and there a vomitory, truly such—the only means of communication between the hidden regions and the stately avenues. Few who passed in the hurry and strife of business or pleasure could imagine so repulsive a background to the brilliant picture. Except the unhappy dwellers in these dismal haunts, none entered but a hasty pedestrian seeking a short cut, or the dispenser of charity, or minister of religion. Here were grim Death's harvest-fields; here the mortality was double that of the population in 'more favourable circumstances.' Not only more deaths, but more living disease; rapid mortality; an accelerated ratio of births; and multitudes of infants coming into existence, year after year, apparently for no other purpose but to die off as fast as possible. Then, again, the liability to fever and fatal sickness on the part of adults was directly the reverse of what the young who chanced to survive required. The more children, the more orphans. Taking a fixed number of parents, the attacks of fever on those between twenty and thirty years of age fell but little short of the total at other ages. From twenty to forty is the most susceptible period; and it is precisely during this time that parents are swept away, leaving orphan families to swell the already overgrown ranks of famine, disease, and crime.

In 1845 the Commission published their second 'Report,' which entered minutely into details, tracing the evils before specified into their remotest ramifications, still taking as types the same fifty towns. There is not much of variety in the evidence: one example may stand for the whole. The differences consist in degree and intensity, not in character and quality. Degeneracy *is* degeneracy, find it where we may; and the overcrowded rooms in country villages are not less unhealthful and fatal to their occupants than those of densely-populated towns. One notable feature about this report was the practical data it established for the carrying out of preventive or remedial measures in the twenty-nine distinct postulates or recommendations by the Commission. These, in brief, are—to place all local sanitary bodies under supervision of the crown; to provide plans and surveys before undertaking new works; to purchase the rights of mill-owners and others, where mill-dams were obnoxious to public health; that all building arrangements should be brought under statutory regulation; that one administrative body should have control over the paving, lighting, and cleansing of towns, the drainage, sewers, cesspools, &c. and the furnishing of water—the supply of this indispensable element to be constant, and laid on without stint to public baths and washhouses, and to numerous fire-plugs in the streets; the rights of existing companies to be purchased whenever desirable; to denounce and abate nuisances by summary process; to provide that factories and steamboats shall consume their own smoke; wide and airy thoroughfares to be opened in close neighbourhoods, and the width of streets to be determined by law; cellar dwellings, with certain exceptions, to be prohibited; no houses to be built without the conveniences required for health, cleanliness, and decency; public buildings and schools to be systematically ventilated; lodging-house keepers to be licensed, and placed under magisterial surveillance; and last, though not the least important, it is recommended 'that local administrative bodies have power to appoint, subject to the approval of the crown, a medical officer properly qualified to inspect and report periodically upon the sanitary condition of the town or district, to ascertain the true causes of disease and death, more especially of epidemics, increasing the rates of mortality, and the circumstances which originate and maintain such diseases, and injuriously affect the public health of such town or populous district.'

Here was a good basis of operations for a sanitary campaign; as will by and by appear, these initiatory proceedings went beyond the 'blue book:' they produced results. It is so much the habit for provincial towns to model themselves after the metropolis, that to commence the rectifying process with London seemed a matter of paramount necessity. Accordingly, in 1847, we had the 'First Report of the Metropolitan Sanitary Commission,' with evidence bearing strongly on the cholera question, its causes and consequences, and, by its reasoning, driving in the wedge of improvement a little further. A second and third Report followed in 1848, succeeded by two Reports from the General Board of Health in 1849, containing forcible evidence on sources of atmospheric contamination and disinfecting processes; and lastly, the 'Report on General Scheme for Extramural Sepulture,' in February 1850. With this voluminous aggregate of information we rest for the present.

We have now, as succinctly as may be, to show how the case has been made out; in how far it is established by the testimony. We may take each village, town, and city throughout the kingdom as central points to so many circles—each circle, as you pass from circumference to centre, exhibiting all the deplorable phenomena attendant on ignorance of natural laws, or on their evasion. Let us begin with an outlying example or two: the first taken from romantic Devon, the county par excellence for invalids, the delight of tourists. Who that has resorted thither will not remember the pleasant aspect of Tiverton, crowning the slope of a hill? Yet defilement lurks within, and health is endangered by offensive open drains and sewers, by which 'the whole town is more or less deteriorated.' And further, 'many of the cottages are built on the ground without flooring; some have neither windows nor doors sufficient to keep out the weather, or to let in the rays of the sun, or supply the means of ventilation.' Imperfect construction is not the whole of the evil: lack of space, of proper accommodation, necessitates overcrowding, and overcrowding leads to consequences which revolt the better feelings of our nature, and which might with propriety remain unrevealed, were it not that the true way to repair errors is to acquaint ourselves with their entire results. Families of six, eight, or more individuals sleep in one room—the majority not unfrequently in one bed: father, mother, grown-up sons and daughters, and young children. Well might one of the witnesses exclaim, 'How could it be otherwise with such families than that they should be sunk into a most deplorable state of degradation and depravity?—or that abhorrent crimes should be committed without compunction?—that unchastity should find the "cunning woman" ready to aid in concealing the shame, or rather the fruit of immorality?' Parish after parish, county after county, all tell the same tale of miserable hovels, called cottages by courtesy, inhabited by a sunken population—children devoured by disease; pure air an impossibility; all order, decency, and delicacy lost in overwhelming squalor. Between Bristol and Bridgewater in the Axbridge Union, the tenements, 'instead of being built of solid materials, are complete shells of mud, on a spot of waste land, the most swampy in the parish.' The medical officer of the Chippenham Union (Wiltshire) 'during three years' attendance on the poor of the district, had never known the smallpox, scarlatina, or the typhus fever to be absent.' The royal town itself is no exception: 'of all the towns visited by me,' writes the reporter, 'Windsor is the worst beyond all comparison.' Everywhere we find something to deplore or condemn. But if the south was bad, the north was no whit better: Dorsetshire had its parallel in Northumberland. Even at the risk of repetition, we cannot forbear quoting a passage from the evidence descriptive of the 'cottages' provided for the use of farm-labourers in the latter county, which, be it remembered, is in England, not in Ireland. The description is by the Rev. Dr Gilly, vicar of Norham. 'The dwellings,' he says, 'are built of rubble or unhewn stone, loosely cemented; and from age, or from badness of the materials, the walls look as if they would scarcely hold together. The wind rushes in through gaping chinks; the chimneys have lost half their original height, and lean on the roof with fearful gravitation. The rafters are evidently rotten and displaced; and the thatch, yawning to admit the wind and the wet in some parts, and in all parts utterly unfit for its original purpose of giving protection from the weather, looks more like the top of a dunghill than of a cottage.'

'Such is the exterior; and when the hind comes to take possession, he finds it no better than a shed. The wet, if it happens to rain, is making a puddle on the earth floor. (This earth floor, by the by, is one of the causes to which Erasmus ascribed the frequent recurrence of epidemics among the cotters of England more than three hundred years ago.) It is not only cold and wet, but contains the aggregate filth of years, from the time of its being first used. The refuse and dropping of meals, decayed animal and vegetable matter of all kinds, which has been cast upon it from the mouth and stomach—these all mix together, and exude from it. Window-frame there is none: the windows do not open. There is neither oven, nor copper, nor grate, nor shelf, nor fixture of any kind: all these things the occupant has to bring with him, besides his ordinary articles of furniture. Imagine the trouble, the inconvenience, and the expense which the poor fellow and his wife will have to encounter before they can put this shell of a hut into anything like a habitable form! This year I saw a family of eight—husband, wife, two sons, and four daughters—who were in utter discomfort, and in despair of putting themselves in a decent condition, three or four weeks after they had come into one of these hovels.'

Again: 'How they lie down to rest, how they sleep, how they can preserve common decency, how unutterable horrors are avoided, is beyond all conception. The case is aggravated when there is a young woman to be lodged in this confined space who is not a member of the family, but is hired to do the field-work, for which every hind is bound to provide a female. . . . Last Whitsuntide, when the annual lettings were taking place, a hind, who had lived one year in the hovel he was about to quit, called to say farewell, and to thank me for some trifling kindness I had been able to show him. He was a fine tall man, of about forty-five, a fair specimen of the frank, sensible, well-spoken, well-informed Northumbrian peasantry—of that peasantry of which a militia regiment was composed, which so amazed the Londoners (when it was garrisoned in the capital many years ago) by the size, the noble deportment, the soldier-like bearing, and the good conduct of the men. I thought this a good opportunity of asking some questions. Where was he going? And how would he dispose of his large family (eleven in number)? He told me they were to inhabit one of these hinds' cottages, whose narrow dimensions were less than 24 feet by 15, and that the eleven would have only three beds to sleep in: that he himself, his wife, a daughter of six, and a boy of four years old, would sleep in one bed; that a daughter of eighteen, a son of twelve, a son of ten, and a daughter of eight, would have a second bed; and a third would receive his three sons of the age of twenty, sixteen, and fourteen. "Pray," said I, "do you not think that this is a very improper way of disposing of your family?" "Yes, certainly," was the answer: "it is very improper in a Christian point of view; but what can we do until they build us better houses?"'*

The dwellings of those whose labour lies below the surface exhibit a similar degree of wretchedness: the 'lodging-shops' of the miners of the north are such, that in comparison the wigwams of the prairie Indians are palaces. In a room 15 feet by 18 were fixed two tiers of seven beds each, each bed being occupied by three or four men or boys, according to circumstances. There was no opening to the external air; fumes of cooking were continually rising from the kitchen beneath; yet here slept from forty to fifty men, succeeding each other in relays during the twenty-four hours—hot, dirty, and dusty. 'Though the beds,' states the reporter, 'had not been occupied for the three nights preceding my visit, the smell was to me utterly intolerable. What the place must be in the summer nights is, happily for those who have never felt it, utterly inconceivable.' And this is said to be 'a fair sample of all the lodging-shops in the country.' Heaven help the lodgers! One of the miners declares the rooms to be unfit 'for a swine to live in,' where fifty men slept in sixteen beds, with 'not a single flag or board on the lower floor; and there were pools of water twelve inches deep. You might have taken a coal-rake, and raked off the dirt and potato-peelings six inches deep.' In such circumstances as these, we can hardly expect the moral virtues to flourish. Poor humanity sinks very low when not upheld by the higher sustaining influences.

Deeper yet: pass from the country into the towns. In the evidence from Lancashire, it is affirmed by Mr Wood—'I have met with upwards of forty persons sleeping in the same room, married and single—including of course children, and several young adult persons of either sex. In Manchester I could enumerate a variety of instances in which I found such promiscuous mixture of the sexes in sleeping-rooms. I may mention one: a man, his wife, and child, sleeping in one bed; in another bed two grown-up females; and in the same room two young men unmarried. I have met with instances of a man, his wife, and his wife's sister, sleeping in the same bed together. I have known at least half-a-dozen cases in Manchester in which that has been regularly practised—the unmarried sister being an adult.' Overcrowding, either in public lodging-houses or in private dwellings, is attended by physical as well as moral debasement. A degenerating process has been observed among the wretched beings who throng these places, whereby they sink into the form and habits of the monkey tribes. 'The state of society' in the monkey-house at the Zoological Gardens is said to afford no inapt specimen of what actually exists among the degraded and indigent of our population. A London magistrate makes a statement which presents another aspect of the downward tendency. 'I have often said,' he observes, 'that if empty casks were placed along the streets of Whitechapel, in a few days each of them would have a tenant; and these tenants would keep up their kind, and prey upon the rest of the community. I am sure that if such facilities were offered, there is no conceivable degradation to which portions of the species might not be reduced.' Some appalling forms of the degradation here alluded to were witnessed in many parts of the country during the construction of railways, by the herding together of troops of brutalised 'navigators' in towns and villages already too thickly populated.

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*The fact at the same time must not be concealed, that the proprietors of cottages experience great difficulty in getting their tenants to live in more than one room—at least such is the case in Scotland, where a family, old and young, will persist in crowding into a single apartment, for the sake of heat and sociability, rather than divide themselves among the beds of two separate rooms.—Ed.

With such a state of things, every degree and tone of improvidence and debauchery would inevitably be associated. Where not an idea existed of the laws of health, over-eating and over-indulgence in intoxicating liquors were sure to prevail; while cleanliness, either of person or of habitation, would be altogether disregarded. What would be the effect of such a polluted mass underlying the other grades of society? In proportion to the degradation, so is the disposition to mischief and violence. Here lie the seeds of crime, the materials for mobs and riots, the instruments of the demagogue and the enemies of order. Here is the plague-spot of modern civilisation; and until it shall be removed our prosperity will be equivocal, and our progress uncertain.

The evils which in rural districts are to a certain extent scattered or sparse are highly concentrated in towns. A dirty cottage is bad, but a dirty street is worse. Like begets like; and from Penzance to Inverness the rule applies without reserve. Glasgow, the wealthiest mart of Scotland, is spoken of by Mr Chadwick as 'the worst he had seen in any part of Great Britain, both in structural arrangements and the condition of the population.' Everywhere five great wants are imminent—want of water, want of air, want of sewers, want of drains, want of exercise-grounds—combined causes of uncleanliness, stagnation, and damp. It is proved beyond a doubt that fevers and other fatal diseases are generated by atmospheric impurity. Rheumatism is induced by damp. Scrofula, tubereuloma, consumption, are especially diseases of civilisation. The more people crowd together, and shut out light and air, the more liable do they become to these and other maladies. No effectual comprehensive measures have ever been taken to prevent this evil, although it has been frequently complained of. A proclamation by Elizabeth in 1602 set forth 'that such great multitudes being brought to inhabit in such small roomes, whereof a great part being very poore, and being heaped up together, and in a sort smothered with many families of children and servants in one house or small tenement, it must needes follow that if anye plague or other universal sickness should by God's permission enter among these multitudes, the same would spread itselfe.' Overcrowding and want of air produce similar effects on the lower animals: rabbits kept in constantly impure air, by way of experiment, became consumptive. It is the same with cows when kept in unventilated stalls. Priestley found that a mouse kept in unchanged air grew weak, and almost lifeless; and that, on putting a second mouse into the same air, it instantly died. 'There can be no doubt,' says Sir James Clark, 'that the habitual respiration of the air of ill-ventilated and gloomy alleys in large towns is a powerful means of augmenting the hereditary disposition to scrofula, and even of inducing such a disposition *de novo*.' Physiologists show that those distressing maladies, goître and crétinism, are due to noxious local influences, chiefly to a stagnant atmosphere; and, as is well known, the complaints are most prevalent in deep valleys, in which the circulation of air is intermittent or languid. In an ill-built village near Amiens, composed of damp and dismal houses, the inhabitants at one time died of scrofula as sheep of the rot, or cattle of murrain: a fire broke out, and swept away a number of the miserable dwellings; they were replaced by others, built more in accordance with the requirements of the human animal; and in these no cases of scrofula have occurred. Granting that the habits of the whole village may have changed somewhat for the better, the fact still remains, that improved structural arrangements neutralise, if they do not destroy, the causes of mischief, and contribute to the permanence of health. Even without seeking for aggravated cases, we might rest with the professional allegation that impure air, among other ill effects, causes deafness: in short, want of ventilation untones—if such a word may be accepted—the individual, and leaves him an easy prey to sensual excitement.

Habitation appears to exert a paramount influence on health quite independent of education, and of what have been often urged as the best preventives of social deterioration—abundant work and high wages; for in New York, where there is always employment for those determined to exert themselves, with good pay, and schooling gratis, 33,000 of the population live in alleys and cellars. In the latter, according to Dr J. Griscom, a trustworthy authority, 'fevers, rheumatism, contagious and inflammatory disorders, affections of the lungs, skin, and eyes, and numerous others, are rife, and too often successfully combat the skill of the physician and the benevolence of strangers.'

'I speak now,' he continues, 'of the influence of the locality merely. The degraded habits of life, the filth, the degenerate morals, the confined and crowded apartments, and insufficient food of those who live in more elevated rooms, comparatively beyond the exhalations of the soil, engender a different train of diseases sufficiently distressing to contemplate; but the addition to all these causes of the foul influences of the incessant moisture and more confined air of underground rooms, is productive of evils which humanity cannot regard without shuddering.'

But atmospheric impurity is not confined to the domiciles of the wretched: in the abodes of royalty, in the drawing-rooms and chambers of the noble, in the halls of the learned, in the temples of pleasure or of worship, ventilation is the exception, not the rule. Architects and builders seem to have been profoundly ignorant of the physiological fact, that man carries a pair of lungs beneath his ribs fitted only to inspire oxygen and nitrogen in their purity. Stand for a moment at the open door of a carriage in which some five or six of the titled and well-born have been riding for an hour closely shut up, and you shall know what a noisome atmosphere really is. Go into a crowded Protectionist or Financial Reform meeting, when the excitement is pretty well up—enter a church or chapel in the middle of the sermon—thrust yourself into a theatre at half-price—or even into the meeting-rooms of any one of our learned or scientific societies—and the sense of foul impurity shall smite you as the breath of pestilence. Your instinctive impulse to flee from the sickening influence at once suggests the remedy. Society, from base to apex, has yet to be indoctrinated with the true principles of the reciprocal relations between vital functions and physical elements.

Again: look at the houses of tradesmen, their shops and workshops; if the evidence is to be believed, they are fertile generators or aggravators of consumption. Dr Guy, who has paid much attention to cause and effect in connection with this disease, contends that consumption is not, as is often urged, a national disease, further than as promoted by national habits. Mr B. Phillips shows also, by a comparison of fifteen different countries in the four quarters of the world, 'that there is no European country, at least in so far as our information extends, in which the people are more free from the disease than England and Wales;' and that it 'is much less prevalent in the present day than it was in the seventeenth and eighteenth centuries.' We may have scurvy and ague among us again, and call them national diseases if we will. In London, as in most large towns, business is the primary consideration: provided the shop be spacious, all sorts of injuries and inconveniences may be tolerated in the rest of the house. Dust and gas contaminate the air of the shop, yet here, and in a gloomy den at the rear, the occupant passes his days. At night, he sleeps in an upper apartment in an atmosphere vitiated by the emanations from below. In such circumstances the vital functions inevitably become languid; the lungs weary for oxygen in its freshness and purity, and at length assume the abnormal state which favours the insidious formation of tubercles. The less of muscular action, the greater the susceptibility to the disease; for which reason artisans are longer-lifed than tradesmen. Then climate is blamed; but Dr Guy asserts that 2500 of the annual deaths from pulmonary consumption in the metropolis are, so to speak, *wasted*, caused by 'deficient ventilation.' The force of this argument may be estimated when we consider that change of air, removal to a healthful situation, frequently effects a cure.

Workshops are still more insalubrious. The man sacrifices to Plutus as well as the master; or perhaps it would be more charitable to say he is under the same imperative necessity of supplying his stomach daily with a certain amount of food. Means of living the aim, though health, morals, and life are sacrificed in the acquisition. The evil extends through a wide range of trades, but exhibits itself most markedly among sedentary occupations. Milliners, dress-makers, and tailors, appear to be especially unfortunate. Many of the garments worn by the well-dressed portion of the community are in too many instances fabricated under circumstances sickening to contemplate. Men are found working in rooms the noisome atmosphere of which could only be matched by that of a felon's cell ere Howard commenced his jail visitations. Reeking hot they sit, often stripped to the skin, to preserve something like a feeling of comfort in the heated temperature; and if more floors than one, becoming more pestilential the higher you ascend. You have the positive, comparative, and superlative—discomfort, disease, death! The present writer will not easily forget a visit he once paid to the workshop of a tailor on the South Bridge, Edinburgh. Some thirty men were at work in the crowded room; the offensive odour from scorched cloth, interfused with exhalations from human lungs and skin, was nauseating in the extreme: to penetrate beyond a foot or two, or to remain, was impossible, and the risk of suffocation or a swoon was only to be escaped by a precipitate retreat. But the horrid taste, the feeling of contamination, was not to be got rid of; nothing short of a bath and an hour's walk on the Calton Hill could remove it. The experience, though transient, has left a painful impression of the miseries to which the working population subject themselves, either from their own ignorance or that of their employers.

We pity the negroes toiling under the hot sun of the tropic or the torrid zone; we interfere by force in favour of those imprisoned in the foul holds of slave-vessels; we convert prisons into penal palaces; and shall we not do something for those whose toil feeds the ever-multiplying resources of the country? Let the principle be recognised, that we have no right to exact the sacrifices now made—let means be taken to provide efficient and practical remedies—and then education may combine its elevating influences, which, failing these, serve but to aggravate the sense of misery.

It is obvious that ventilation, to be complete and effectual, must derive its aërial currents from a pure source. But the atmosphere of large towns is anything but pure: the Registrar-General calls it a 'disease mist;' and not the least to be dreaded among causes of contamination are intramural graveyards—the burying of the dead in the midst of the living. We have already alluded to Mr Chadwick's Report on Interment in Towns; it contains a body of information from trustworthy sources on the question at large—the deadly effects of animal decomposition, the generation of miasm, the spread and communication of morbific matter. The presence of animal exuviæ in the soil is injurious in more ways than one: superiorly, by the evolution of gaseous products; inferiorly, by percolation through the contaminated soil, and the consequent tainting of springs and wells. Evidence to this effect may be found in impromptu burial-grounds: fields of slaughter have sometimes proved as fatal to the survivors as to the slain. 'At Ciudad Rodrigo,' as Sir J. Macgregor states in his account of the health of the army, '20,000 dead bodies were put into the ground within the space of two or three months; this circumstance appeared to influence the health of the troops, inasmuch as for some months afterwards all those exposed to the emanations from the soil, as well as obliged to drink the water from the sunk wells, were affected by malignant and low fevers and dysentery, or fevers frequently putting on a dysenteric character.'

'In the metropolis,' continues the Report, 'on spaces of ground which do not exceed 203 acres, closely surrounded by the abodes of the living, layer upon layer, each consisting of a population numerically equivalent to a large army of 20,000 adults, and nearly 30,000 youths and children, is every year imperfectly interred. Within the period of the existence of the present generation, upwards of a million of dead must have been interred in these same spaces.'

From seven to ten years, less or more, according to temperature, nature of the soil, and other circumstances, are stated as the period required for the decay of a human corpse; during all this time gases more or less deleterious are evolved. The quantity of carbonic acid is so great, that graves twenty feet in depth have become filled in the course of a single night; in some instances Dr Reid has drawn off this gas by a ventilating process; in others, the diggers have suddenly died by incautiously descending into the fatal pit. It is no uncommon occurrence for meat on the premises of butchers in the vicinity of Westminster

Abbey to acquire an offensive taint in the course of a few hours. Want of space is the prime cause of this noxious influence; the 'seven years' required for decomposition, though recognised in theory, are disregarded in practice. The abominations, the ill health endured by those who live close to London churchyards, almost exceed belief. The deeds perpetrated in the Spa Fields burial-ground, which attracted public attention in 1845, will long be remembered. For a length of time coffins were dug up and burned with their contents, to make room for new interments; the long hair of women was cut off for sale; and dentists were supplied with teeth from the exhumed corpses! We do not object to cremation; we think it the best mode of disposing of the dead; but that a state of things should exist which leads to the committal of enormities so atrocious as those above referred to, is not to be tolerated. It is one that calls for the speediest and severest exercise of governmental authority.

It may be painful to question the propriety of restraining the exercise of human sympathies, especially when evoked by deep affliction; but when we find the practice of retaining corpses for a long time unburied, surrounded by a bereaved family or other inmates, productive of harm, we are compelled to obey a sense of duty, and declare the practice to be as mistaken as it is mischievous. The evil becomes most flagrant among those of narrow means—the multitudes of the working population who inhabit one, or at most two rooms. Frequently when death has been the consequence of some loathsome disease, the body has been kept for days at one side of an apartment, on the other side of which the family have been living, cooking, and taking their meals. Here also injurious consequences ensue, moral as well as physical, as instanced in a striking passage of the Report. The corpse is never absent from the sight of the survivors; 'eating, drinking, or sleeping, it is still by their side; mixed up with all the ordinary functions of daily life, till it becomes as familiar to them as when it lived and moved in the family circle. From familiarity it is a short step to desecration. The body, stretched out upon two chairs, is pulled about by the children; made to serve as a restingplace for any article that is in the way; and is not seldom the hidingplace for the beer-bottle or the gin if any visitor arrives inopportunely. Viewed as an outrage upon human feeling, this is bad enough; but who does not see that when the respect for the dead—that is, for the human form in its most awful stage—is gone, the whole mass of social sympathies must be weakened—perhaps blighted and destroyed?'

The remedy for this particular evil forms part of the proposed remedial plans which we shall have presently to notice. Immediately, or within a few hours after death, as peculiar circumstances might warrant, the body should be removed to a building, to be erected in the precincts of all cemeteries, and there lie under proper custody until the time of interment, which should in all ordinary cases be within three days. Speedy removal of a corpse after death need not involve the apprehension of burying alive. In any and every case where suspended animation was suspected, the body would be placed in an apartment specially contrived, so that the slightest indication of returning consciousness should be at once attended to. The difficulties in the way of such a reform as this are great, though not insurmountable: long-established custom and a host of prejudices are to be overcome besides the sympathies of sorrow. The popular notion is, that prompt removal of a corpse would be 'cruel;' and we can only look to knowledge and enlightenment for rectification of the error; to show that the lower a people are in civilisation, the more unnecessary attentions do they bestow on mortal clay; that it is the animate spirit which we love, not the perishable carcase; that vain pomp is worse than useless. Large sums are lavished on funeral trappings which would prove of lasting benefit to those who have to pay for them, and the incongruity of the emblems with the present condition of society is lost sight of. Those accustomed to witness the return of 'mourning-coaches when the funeral's done,' will estimate the array at its true value, especially when contrasted with an unobtrusive ride to the cemetery, there to assume the funeral garb, and having paid the last solemn duty to the departed, to return with a chastened spirit that seeks not to attract the vulgar gaze.

Then the expense! Funerals afford grand opportunities for plunder. The number of undertakers in London is estimated at from 500 to 1000: many of them merely receive orders, on which a commission is obtained: while a second, and sometimes a third party, does the work, so that three profits have to be paid. One of these middlemen 'got' a new suit of clothes for himself out of the 'remuneration' from a common mechanic's funeral. A labourer's funeral costs from £3 to £5; working tradesmen pay from £10 to £12; people of 'moderate respectability,' £60; a clergyman's widow was charged £110 for her husband's funeral, she having ordered 'what was respectable;' while to gentlemen and the superior ranks the cost is from £200 to £1000. From detailed statements, collected with a view to ascertain the fair and honest cost of interments, it appears that a 'walking funeral,' exclusive of burial fees, can be undertaken at specified rates—'For a labouring-man, £1, 10s.; for a labourer's child, 15s.; for a tradesman, £2, 2s.; for a tradesman's child, £1, 1s.; for a gentleman, £6, 7s. 6d.; for a gentleman's child, £3, 10s. The expenses of hearses and carriages would depend on the distance, and would make from one to two guineas each carriage extra.' This is near the rate of charges made for interments in Paris, and admits of the funeral being conducted in a solemn and decorous manner: economy in this respect not involving shabbiness. The 'proximate estimate of the expense for the total number of funerals in England and Wales, in one year,' is stated as £4,871,943. The useless and excessive outlay in this large amount, if applied to sanitary arrangements, would constitute an immediate and effectual means of preventing many of the evils complained of. The necessary structural reforms in ordinary dwelling-houses may be made at a charge of £1, 5s. 10d., or less, payable as instalments over a period of twenty or thirty years. In Liverpool alone, with proper precautions, £30,000 might be saved in funeral expenses yearly.

One point cannot be too strongly urged—and that is the necessity for prohibiting at once and for ever the practice of burial in towns or in close proximity to human habitations. Cemeteries of large extent may be laid out on waste lands adjoining railways, so as to be readily accessible; and the building of dwelling-houses within a mile of these restingplaces of mortality should be rigidly forbidden. To provide for the 50,000 annual deaths in London, and allow ten years to elapse before disturbing the same ground, 444 acres would be required—an area equal to that of three of the West-End parks put together. We need not go far for precedents: extramural interment is the rule on the continent, as it was among the primitive church. On the continent, too, and in the United States, we find the appointment of a public-health officer an essential part of sanitary police. In times of distress and disease among the poor, this official would act as referee, and be at hand to give advice and assistance: his presence would operate as a check on burial-club murders and secret poisonings. Inquests on sudden but natural deaths would be unnecessary; and his supervision would be a means of protecting the poor from extortionate charges at funerals, and from 'the various unforeseen contingencies that occur to perplex and mislead the prostrate and desolate survivors on such occasions.' We are led to believe, from the Report on Extramural Sepulture, mentioned in a former part of this paper, that the burial-in-towns' grievance will not be suffered to exist much longer. It is proposed to obtain two acts, one for London, the other for the country. The present practices, as urged above, are not to be permitted; fees are to be reduced, and not more than one corpse is to be buried in a grave. A site on the banks of the Thames (said to be at Erith) has been surveyed for a general cemetery, eligible in all respects for the purposes required. It can be reached by steamboat from London Bridge in about an hour, or by railway. Reception-houses for the dead are to be built in various localities near the river, so that corpses may be at once removed from among the living.

Carelessness of infantile life is a prominent characteristic of some of our densely-populated manufacturing towns; to meet this, the Registrar-General recommends the establishment of dispensaries for the young. 'How pitiful,' he observes, 'is the condition of many thousands of children born in this world! Here, in the most advanced nation of Europe—in one of the largest towns of England—in the midst of a population unmatched for its energy, industry, and manufacturing skill—in Manchester, the centre of a victorious agitation for commercial freedom—aspiring to literary culture, where Percival wrote, and Dalton lived—13,362 children perished in seven years over and above the mortality natural to mankind. These "little children," brought up in unclean dwellings and impure streets, were left alone long days by their mothers, to breathe the subtile, sickly vapours—soothed by opium, a more cursed distillation than "hebenon"—and when assailed by mortal diseases, their stomachs torn, their bodies convulsed, their brains bewildered, left to die without medical aid—which, like Hope, should "come to all"—the skilled medical man never being called in at all, or only summoned to witness the death, and sanction the funeral!'

The fatal practice of giving opiates to children here alluded to is one that prevails, especially in Lancashire: nearly every town is implicated in the melancholy result. 'Godfrey's Cordial,' 'Mother's Blessing,' 'Infants' Preservative,' and other similar deleterious compounds, are sold by hundreds of gallons as 'quietness' for children; and in this way numbers are slept to death. According to Dr Lyon Playfair, 'the mother goes out to her work in the morning, leaving her child in charge either of a woman who cannot be troubled with it, or with another child of perhaps ten years old. A dose of *quietness* is therefore given to the child to prevent it being troublesome.' Again at dinner-time and in the evening is the deadly potion administered, until the victim of parental ignorance dies, or becomes deformed or idiotic. And what is worse, the death is frequently intentional: the child is 'entered' at sometimes a dozen burial-clubs, and the wretched parents sell the life of their offspring for the insurance money.

It is interesting, painfully so in the present instance, to mark the parallelism between cause and effect in places remote from each other, and in different states of society. The assistant-surgeon at Allahabad complains of certain 'savage customs' prevalent in that city, whereby 'at or about the second month of its infantile life every child is made to take opium, wine, or any other narcotic drug to lull it to sleep. This unnatural and cruel practice has gained so firm a footing, in this city in particular, that even the rich mothers, who can easily afford maid-servants for their children, nay, who have them already, indulge in it frequently. If for a time they abstain, it is with no very good or great results. The ample opportunity afforded to the mother by this inhuman course, and the very few number of times she is required to suckle the child, induce her soon to overlook the evil and dangerous consequences, and to resume the task of destruction.'

Next to want of pure air, we may consider the want of pure water—of a full and steady supply of the indispensable element—a prominent cause of disease and demoralisation. Efficient drainage and sewerage depend on a copious supply of water: without water, alleys, streets, and roads cannot be kept properly clean; for want of water, thousands of the population are dirty and filthy in person and habitation. Want of water in constant pressure increases the risk of fire, and keeps up the rates of insurance. In crowded districts, where every room of nearly every house is separately tenanted, a scarcity of water is severely felt, and uncleanliness is inevitable. The labour of descending flights of stairs to fetch water from a 'stand-cock' is too great to admit of a free and sufficient use of the precious fluid. Equivocal vegetables, purchased from unsavoury hucksters, are cooked without any process of washing; and after the boiling of 'morbid meat,' the liquor is made to do duty in other domestic operations. Two or three instalments of under-clothing are washed in unrenewed water, which then, instead of being thrown away, is used in scrubbing the floors and stairs. Hence noxious exhalations, and the foul smells which cling to the abodes and the persons of those to whom the epithet 'great unwashed' has been applied. How are people to wash without water? We are not Mussulmans, that we should make-believe to perform ablutions with 'invisible soap and imperceptible water.' When people become accustomed to dirt, when its presence is either unperceived or unfelt, there is no limit to the downward tendency. Perhaps the most repulsive feature connected with the want of water is the foul condition of the *lieux d'aisance:* it is hard to conceive the depravity of sentiment which tolerates the presence, the contact even, of human *egestæ*—which makes no effort to avoid or remove the most loathsome of excrementitious matters. Apart from the horrible physical contamination, the moral contamination is conspicuous. Each degree of squalor finds its peculiar *locus.* Let any one perambulate the Canongate, Cowgate, and their purlieus, in the Old Town of Edinburgh, at early morn, at mid-day, and again in the evening, let him note the habits and characteristics of the population therein domiciliated, and then extend his explorations to the 'back streets' of the New Town. He sees an essential difference: bad as the one may be, the other is worse immeasurably—in fact beyond the reach of adjectives to qualify. So of Glasgow, so of Liverpool, so of Manchester, so of Sheffield, so of London, and of every other place where ignorance or cupidity has stifled the disposition to improve.

From a calculation made on the basis of the last census, there are in London 300,000 cesspools, whose contents form an exhaling surface of 2,700,000 feet, nearly 62 acres, or 17,550,000 cubic feet. This, in the words of the authority, 'is equal to one enormous elongated stagnant cesspool 10 miles in length, 50 feet in width, and 6 feet 6 inches in depth, which would extend through London, from the Broadway at Hammersmith to Bow Bridge over the river Lea—a distance of 10 miles. If such a gigantic cesspool of filth were to be seen, it would fill the mind with horror; but, as is shown above, a vast number of small ones, which, added together, equal it in extent, is dotted all over the town; in fact it may be said that the ground, in old districts more particularly, is literally honeycombed with the barbarous things.' The atmospheric pollution which such a hoarded conglomeration must necessarily produce can hardly be less fatal than the paludal miasma of the Campagna, or of the equatorial regions of Western Africa. If not in itself a cause of disease, it aggravates the effect a thousandfold. With our improved social habits, we no longer allow our streets and kennels to be defiled with the excretæ of a population; the operations of nightmen are viewed with increasing disgust. Why, then, should we be content to live—to go through our daily avocations—expand ourselves in domestic or intellectual enjoyments—pour out our hearts in loving sympathies, with a pestiferous accumulation of putridity but a few inches below our feet? If the nuisance were irremediable, we might resort to fumigations and counteracting perfumes, as did our forefathers, and endeavour to be thankful that things were no worse. But the remedy is as simple as the evil is offensive. With an ample supply of water properly distributed, and applied in dwelling-houses and underground, all these noxious matters may be at once carried away. In a well-constructed sewer, the continuous flow of a small stream of water effects by simple and innoxious means a transport and removal which now cost so dear in every sense of the word.

The reservoirs at the Fairmount works, by which Philadelphia is supplied, contain 22,000,000 gallons. The water is distributed through 97 miles of iron pipe. The daily consumption in 1848 was 4,275,352 gallons, for which the receipts were nearly 117,000 dollars. Three water-wheels lift the quantity required at a daily cost of four dollars, and two men, working 12 hours alternately, do all the duties connected with the supply, which, besides private service, includes 851 fire-plugs, and 319 'public hydrant pumps.' New York, too, has its aqueduct 40 miles in length, 8 feet high, and 7 wide, which will convey 30,000,000 gallons daily; the distributing reservoir holds 21,000,000 gallons, and there are more than 180 miles of pipe laid throughout the city. Boston also will be abundantly supplied when the aqueduct which is to bring water from Cochituate Lake, twenty miles distant, shall be finished. The source will afford 10,000,000 gallons every day: the capacity of the reservoirs is 70,000,000 gallons. Such undertakings are worthy of all praise.

London is supplied with water by eight principal companies, and two or three minor ones, who furnish, according to Mr Fletcher's calculation, as read before the Statistical Society, 330,000,000 hogsheads yearly; being 10,140,500 cubic feet per day, or at the rate of 30 gallons for each individual of the population. Yet it is notorious that there are in London 70,000 houses, occupied by more than half a million of inhabitants, which have no supply whatever. It is in this class of dwellings that the miserable make-shifts take place alluded to above, as exhibited most markedly in the east of London, where some hundreds of 'stand-cocks' scattered over the 'low neighbourhoods,' with an intermittent supply, afford but scanty means for comfort or cleanliness.

The thirty gallons per day to each individual is thus shown to be practically a fallacy. Yet were it true, certain essentials would still be lacking. We want water, but good water, sweet and wholesome—not diluted mud or sewer refuse. The Thames, in its course of 160 miles, receives the refuse outpourings of 223 cities, towns, and villages; the metropolis discharges its pestilential tribute to the noble river through 130 sewers, to the amount of 30,000,000 gallons daily, or 130,000 tons. Among a population of 2,000,000, the mere daily ablutions must contribute largely to the causes of contamination; add to this the excrementitious matters, 'the washings of foul linen, the filth and refuse of many hundred manufactories, the offal and decomposing vegetable substances from the markets, the foul and gory liquid from slaughter-houses, and the purulent abominations from hospitals and dissecting-rooms,' and an idea may be formed of the quality of the fluid which no inconsiderable portion of the inhabitants of London are doomed to drink, to use for all domestic purposes every day of their lives, unless, indeed, they abjure the impure element altogether, and consume it as disguised by brewers, distillers, and licensed victuallers.

The Lambeth Company, which distributes water over a large part of the low, flat district on the south of the Thames, take their supply from the river near to Charing-Cross Suspension Bridge; they pump it at once, without any intermediate process of filtration, into the cisterns of their customers. Now it is worthy of remark, that during the late visitation of cholera the deaths were more numerous on the Lambeth side of the river than in any other part. The maximum mortality fell in Rotherhithe, a district supplied with water from the Thames near Chelsea Hospital. The whole of this peninsulated region lies low, as before stated, some feet below high-water mark—a fact not to be lost sight of in theorising on the relation between impure water and choleraic phenomena. But when we find the more elevated districts—supplied by the New River, and the companies deriving their supplies from Hampstead and from the Thames at Kew and Hammersmith, sources of *comparative* purity—escaping almost intact, we cannot resist the inference that bad water induces an abnormal condition in those who drink it favourable to the encroachments of disease. From time to time, a panic has seized the public mind on the subject of Thames water; and companies have filtered on a large, and individuals on a small scale, hoping to obtain a drinkable beverage.

In 1828, a committee of medical and scientific gentlemen appointed by parliament drew up a report on the water question. We have quoted from this report above. As regards the mechanical cleansing, they considered 'it obvious that water receiving so large a proportion of foreign matters as we know find their way into the Thames, and so far impure as to destroy fish, cannot, even when clarified by filtration, be pronounced entirely free from the suspicion of general insalubrity.' Analyses of water engaged the attention of Berzelius during some of the latter years of his life: that great chemist found it impossible to divest water, once contaminated by human excretæ, of its noxious principles.

The subject is a fertile one, commercially as well as physiologically. Since the Reports of the Health of Towns' Commission were published, many schemes and projects have been put forward with a view to a pure and efficient water-supply. Artesian wells, and distant lakes and streams, are talked about as available sources; but no one plan has yet appeared which combines all the requisites. Forcible objections are urged against increasing the already too numerous associations of irresponsible companies. One great controlling and administrative authority would appear to be the essential principle of true sanitary reform.

In addition to the vitiating causes already indicated, the monster smoke-nuisance is a pre-eminent grievance. Manchester, Stockport, and others of our northern manufacturing towns are flagrant examples of a prejudicial excess of smoke. Wherever the fuliginous vapours abound, there vegetation languishes, in most cases perishes—the deadening influence extending even to outlying suburbs. That which is fatal to vegetable life would, by analogy, be fatal also to animal existence: some things which may be taken into the stomach without harmful consequences, are eminently injurious when brought into contact with the lungs. People have eaten decomposing animal substances, and lived, when the gases evolved in the process of decomposition would have destroyed life. The air of large towns conveys to a person fresh from the country, and in a normal state of health, a sense of suffocation. This feeling is experienced by town-dwellers themselves in rainy or damp weather. The carbon of the smoke then becomes saturated, and sinks, and the subsidence of the murky canopy prevents that ventilation which in clear open weather takes place in a greater or lesser degree. In Manchester, the rain-water is harder than that of springs in the neighbouring hills—an anomaly only to be accounted for by the carbonaceous overcharge in the atmosphere. Hence the busy seats of manufacture, whose inhabitants, above all others, require energy, activity, and spirit, are compelled to work at a discount, and the industrial barometer is depressed in proportion to the aërial surcharge and debasement. But the working population are not the sole sufferers. 'Even upon the middle and higher classes the nuisance of an excess of smoke, occasioned by ignorance and culpable carelessness, operates as a tax, increasing the wear and tear of linen, and the expense of washing, to all who live within the range of the mismanaged chimneys. In the suburbs of Manchester, for example, linen will be as dirty in two or three days as it would be even in the suburbs of London in a week.'

Londoners will hardly be reconciled to their own smoky annoyance by the knowledge that a greater exists two hundred miles to the northward. It was a subject of complaint a couple of centuries ago. The Earl of Strafford, writing to one of his friends after an illness, says, 'I recovered more in a day by an open country air than in a fortnight's time in that smothering one of London.' 'As the air is,' says old Burton, 'so are the inhabitants—dull, heavy, witty, subtle, neat, cleanly, clownish, sick, and sound.' The quaint humorist was nearer the truth than he perhaps thought. To say nothing of breweries, distilleries, and their countless rivals of all degrees, the twelve gas companies of London burn 180,000 tons of coal in the twelvemonth—no small item in the sooty aggregate. In fact the veriest smoke-denouncer of the present day would need but to reproduce honest John Evelyn's complaint, as set forth in his 'Fumifugium.' In his day even the evil was already obnoxious; for he speaks of the 'hellish and dismal cloud of sea-coal,' and of the chimneys of brewers and traders, whose 'belching sooty jaws do manifestly infect the air more than all the chimneys of London put together.' Plants and flowers, too, would no longer grow where the fumes penetrated. The author of 'Sylva' took part in preparing an act to suppress the nuisance; but nothing came of it, and the same negative result has continued down to our own day.

A twofold necessity would seem to exist for purification of the air in towns, seeing that not only are the lungs of the community defrauded of their fair and natural quantum of oxygen, but the water is deteriorated in quality by absorption of impurities from the atmosphere. Dr Angus Smith, in a report on the air and water of towns, read to the British Association, shows the deterioration to consist in more than the increment of carbonic acid, and to be due to organic matter, which all animals throw off in expiration. He has collected condensed breath from the inside of windows in crowded rooms, and submitted it to chemical analysis. 'If allowed,' he observes, 'to stand some time, it forms a thick, apparently glutinous mass; but when this is examined by a microscope, it is seen to be a closely-matted confervoid growth, or, in other words, the organic matter is converted into confervæ, as it probably would have been converted into any kind of vegetation that happened to take root. Between the stalks of the confervæ are to be seen a number of greenish globules constantly moving about, various species of volvox, accompanied also by monads many times smaller. When this happens, the scene is certainly lively and the sight beautiful; but before this occurs, the odour of perspiration may be distinctly perceived, especially if the vessel containing the liquid be placed in boiling water.' It is worthy of note that even after many days of rain, this organic matter may still be detected in a town atmosphere.

The doctor's summing up ought to be widely known. We reproduce some of his conclusions here—they may serve as sanitary texts. *Imprimis*, that the pollution of air in crowded rooms is really owing to organic matter, not merely carbonic acid; that this may be collected from the lungs or breath, and from crowded rooms indifferently; that it is capable of decomposition, and becomes attached to bodies in an apartment, where it probably decomposes, especially when moisture assists it; that this matter has a strong animal smell, first of perspiration, or, when burnt, of compounds of protein; and that its power of supporting the life of animalcules proves it to contain the usual elements of organized life.

Next he explains the chemistry of filtration, and alleges that 'water can never stand long with advantage, unless on a very large scale, and should be used when collected, or as soon as filtered.' Small filters do their work imperfectly; the larger they are the better. The vapid, spiritless taste of water in large towns is caused by the water purifying itself from the noxious matters which it receives from sewers and drains by percolation or otherwise. The corrective recommended for this absence of living flavour is the addition of a small quantity of acid. Again—'The slightly-alkaline state into which the soil is put at certain periods of the year, give it a facility for emitting vapours.' Here we seem to have a glimpse of one of the manifold operations of telluric chemistry: it would be interesting to learn whether any, or what condition of the soil favours the development of cholera; or whether the diffusion of ammonia in the atmosphere, by facilitating the evolution of organic particles in hot weather, has any part in the phenomena of epidemics.

It would far exceed our limits to dissert at length on all the causes which deteriorate public health, to the prejudice of public and private economy and morals. Most of them have been brought forward directly or indirectly, and we can only particularise one or two others before approaching the subject of remedial measures. Perhaps but few persons, until of late, had ever thought that dirt and impurity involved such fearful consequences, such an amount of sorrow and suffering. Dirt, danger, disease, death, form an alliterative series fraught with highly-important considerations which compel attention. It costs more *not* to have paved streets, drains, and sewers, and a constant supply of water in the house, than to have all these conveniences. In Manchester, Leeds, and other towns, as shown by concurrent testimony, the more a street is neglected by the municipal authorities, the more will it be neglected by those who inhabit it. If a street be kept clean, there is a hope that the dwellers therein will follow the cleanly example; but it is manifestly a delusion to expect purity to flourish in a swamp of impurity. Classify the fever patients in hospitals, you will find that nine out of ten come from the unpaved and undrained districts. Dr Baron Howard remarks, that in such quarters 'whole streets are unpaved, and without drains or main-sewers; are worn into deep ruts and holes, in which water constantly stagnates; and are so covered with refuse and excrementitious matter, as to be almost impassable from depth of mud, and intolerable from stench.' This is said of Manchester, where, 'of 687 streets inspected by a voluntary association, 248 were reported as being unpaved, 112 ill-ventilated, 352 as containing stagnant pools, heaps of refuse, ordure, &c. . . . Of the 586 streets of Leeds, 68 only are paved by the town—that is, by the local authorities; the remainder are either paved by owners, or are partly paved, or are totally unpaved, with the surfaces broken in every direction, and ashes and filth of every description accumulated upon many of them. In the manufacturing towns of England, most of which have enlarged with great rapidity, the additions have been made without regard either to the personal comfort of the inhabitants or to the necessities of aggregation. To build the largest number of cottages on the smallest allowable space, seems to have been the original view of the speculators; and the having the houses up and tenanted, the *ne plus ultra* of their desires. Thus neighbourhoods have arisen in which there is neither water nor out-offices, nor any conveniences for the absolute wants of the occupiers.' Here we have a significant hint—one out of many—that 'cupidity of proprietors' is justly chargeable with a great amount of public misery.

In all this there is not only loss of character, health, and life, but loss also of a source of revenue to towns, and of materials highly valuable to the agriculturist. Assuming that 15,000 tons of solid excrementitious matter are daily cast into the sinks and sewers of London, and that each ton is worth 10s. when converted into *poudrette*, or marketable manure, there is in the present waste of such materials a daily loss of more than £7000, and this superadded to the often-urged obnoxious consequences of such waste. If we draw up a debtor and creditor account in this, as in any other part of the subject, the balance is always against the hitherto imperfect arrangements. Wherever improvement has been attempted, although on no grand comprehensive scale, the result has proved favourable. In Aberdeen the streets are swept daily at a charge of £1000 yearly; the refuse is worth £2000. In Perth, again, the cost of cleansing is £1300 annually, while the value of the sweepings is £1730. With our increased knowledge of the chemistry of agriculture, and of the necessity for maintaining a due balance between the animal and vegetable kingdoms—between the physical and the organic—it is little creditable to us, as a people apt to avail ourselves of all promising means of trade, that the most valuable of fertilising substances, the richest in nitrogenous principles, should be poured forth as worthless. Our area of waste lands would soon be diminished were a proper economy of manures once established. In the cities and towns of China, tubs and tanks are placed in the streets for public use, and at the close of each day are emptied into barges, which, by means of the numerous canals, convey the prized freight to all the farms of the district. Here we see a rational appreciation of useful elements: whatever system of sewerage may be adopted, it must, to be thoroughly efficient, provide for a proper conservation and employment of the animal refuse. Its distribution in a highly-diluted state to wide districts, by means of pipes laid underground, has been recommended; but taking all circumstances into consideration, we believe that its conversion into the solid form, or as *poudrette*, would be the more desirable process, and the most available for general transport. The invigoration which commerce is destined to feel under the relaxation of restrictive laws will doubtless stimulate ingenuity to some acceptable solution of the difficulty.

Another instance of combined waste and noxiousness is to be found in intramural slaughter-houses. In this, as in so many other nuisances, modern civilisation is remarkably tolerant. That which the Plantagenets and Tudors regulated by statutory enactments, is now left in a great measure to legislate for itself. There are 4000 butchers in London; and to supply the vast demand ever concentrated in the metropolis, nearly two millions of animals of all sorts are sold at Smithfield in a year. A cattle-market within the walls, nay, in the heart of a large and densely-populated city, is one of those civil incongruities which, familiarised by long custom, we look on as matters of course; and yet a few moments of calm reflection, aided by common sense and pecuniary disinterestedness, would convince any one of the egregious mistake. Smithfield was once outside of London—the natural situation for a quadrupedal Exchange; in fact out-of-town cattle-markets will complete the amelioration to be commenced by out-of-town cemeteries. The city corporation derive an annual profit of nearly £4000 from the present market, the area of which is scarcely one-fourth of what is really needed to afford proper accommodation to the herds and flocks of live-stock, the 160 salesmen, the 900 licensed drovers, and the multitude of buyers, whose purchases form an annual aggregate of £7,000,000.

The other markets of London—north, south, east, or west—are reproductions of the Smithfield nuisance on a smaller scale: most of them are infested by slaughter-houses—a very scandal to social police. Whether on the surface, or, as is frequently the case, in an underground cellar, the emanations from the noisome garbage taint the meat exposed for sale at the stalls, and add to the already existing overcharge of atmospheric impurity. From fifty to sixty sheep, or ten to twenty cattle, are slaughtered daily in some of these reeking vaults. We may, however, hope that the nuisance here specified, as well as others, will ere long be looked back on as errors of the past; for by the Report of the Commission of Sewers for the City of London, published a few weeks since, we learn that slaughter-houses within its jurisdiction are now licensed, and cleansed in accordance with the regulations, and that other local evils are in process of mitigation or removal. We gladly record this step towards essential efficiency in corporate supervision.

Putting the physical and economical advantages against the 'interests,' there is no valid reason why such nuisances should not be abated—the rather as the precedents for such a step are as complete as could be wished. The two cattle-markets of Paris are many miles distant from the city; all animals intended for consumption in the capital must be killed at one or other of the five abattoirs, or slaughter-houses, built at some distance without the walls. These edifices were erected in 1810, in obedience to a decree by Napoleon, and were so perfect in their arrangements, as to have never been improved on. The regulations for securing entire cleanliness are admirable, and are enforced rigorously on the butchers and killers employed on the premises: a task greatly facilitated by the ample space afforded and the means for thorough ventilation and circulation of the air. The original cost of the abattoirs was £680,000; the revenue derived from them in 1846 amounted to £47,608; while the expenditure being £4958, a net profit remained of nearly £43,000. Abattoirs are not altogether unknown in England: there is one about three miles from Liverpool, which, while remunerating the proprietors, has relieved the town, though not so completely as could be wished, of a mischievous source of annoyance. The inhabitants of the great port of the Mersey will find but little good in half-measures; nothing short of entire prohibition of intramural slaughtering will meet the necessities of the case. Norwich also has its abattoir, on too small a scale, however, to be efficiently remedial as well as profitable.

The removal of the metropolitan cattle-market is no new question; it was eloquently discussed in speech and writing nearly a hundred years ago; and the government Commission lately appointed to collect evidence, and report on the Smithfield case, will find much work already done to their hands in Mr Gwynn's statements, published in 1766, as well as in the memorial presented to the Lords of Council for Trade in 1808. In reply to the latter, the Lords determined to suppress the existing market, and remove it to a site of not less than twelve acres beyond the walls. Unfortunately this praiseworthy decision was not acted on, chiefly because of supineness on the part of the authorities, and opposition of interested individuals; and it was not until 1828 that attention was again drawn to the subject. However, in parliamentary phrase, the parties took nothing by their motion. In 1835 Mr Perkins erected a spacious and well-provided cattle-market at Islington, with a view to divert the trade from the heart of the city, and thereby abate a nuisance both dangerous and disgusting; but the undertaking proved a failure, and until within the past year not a hoof was lodged in the roomy receptacles. The decision of the Commission now sitting will doubtless be a final one: we trust it may also be the right one, and that through them sanitation may yet gain somewhat in completeness.

Such, so far, may be considered as the essential grievances obnoxious to public health, and the cause of unparalleled evils, physical and moral, social and individual. But the conclusions have been disputed; they have been questioned as theoretical, and unsupported by fact. A very slight acquaintance, however, with the history of medicine, coupled with that of interior national economy, will satisfy all the inferences as to cause and effect. Ample confirmation is afforded by the annals of every people whatsoever, that their wellbeing and advancement depended not less on obedience to laws of health than to political laws. Mr Walker furnishes a case in point:—'In ancient Egypt,' he states, 'plague was unknown. Although densely populated, the health of the inhabitants was preserved by strict attention to sanitary regulations. But with time came on change, and that change was in man. The serene climate, the enriching river, the fruitful soil remained; but when the experience of two thousand years was set at naught—when the precautions previously adopted for preserving the soil from accumulated impurities were neglected—when the sepulchral rites of civilised Egypt were exchanged for the modern but barbarous practices of interment—when the land of mummies became, as it now is, one vast charnel-house—the seed which was sown brought forth its bitter fruit, and from dangerous innovations came the most deadly pestilence. The plague first appeared in Egypt in the year 542, two hundred years after the change had been made from the ancient to the modern mode of sepulture; and every one at all acquainted with the actual condition of Egypt will at once recognise in the soil more than sufficient to account for the dreadful malady which constantly afflicts the people.'

Here we find one of the remarkable instances in which it is possible to assign a primary habitat to a disease on distinct grounds. The plague is peculiar to countries bordering on the Mediterranean; but its breeding-place is a district on the coast of Egypt adjacent to Alexandria. In former times the Egyptians were very cleanly in their habits: they made openings in the walls of their rooms to promote ventilation, and kept up a continual descending current of air in their chambers by means of the *mulquf*, an apparatus constructed on the roof of their houses; still used by their descendants, but much less effectively. Now, the great mass of the population live huddled together in miserable dwellings. The system of burial among them is most imperfect: the grave is generally not more than eighteen inches in depth, and in many instances the body is covered only by a thin coat of sand. There are thirty-five burial-grounds in Cairo, each one a centre of pestilence. Dogs and hyenas prowl about them at night, and feast on the corpses; millions of flies, generated by heat of climate and putrefaction, infest the air during the day, and sometimes by contact communicate plague to the passers-by. Egypt is not alone in this desecration of burial-grounds: in some parts of Ireland dead bodies are not unfrequently exhumed and devoured or mutilated by packs of ferocious dogs.

Again: one of the assistant-surgeons under the medical staff of India directs attention to the *takias*, or burial-grounds, of which there are 300 in and about the populous city of Benares. They are, to quote his own words, 'productive of mischief . . . . and as the poor do not mind to bury the dead deeper than they think it necessary, a few years' rains expose them to the action of the atmospheric heat and air. . . . '. Effluvia from putrid dead bodies, under favourable circumstances, have been known even in Europe to nearly depopulate a number of villages; and that in India they will produce similar effects, but of an aggravated nature, is matter of no surprise.' Here we have a definite effect arising out of a definite cause; but other phenomena are not so easily explained. It would be interesting could we know why scarlet fever should have originated in Arabia in the sixth century, and why no record of hooping-cough exists prior to 1510, when it prevailed fatally in Paris, and has subsequently destroyed great numbers in all parts of the world. Cholera, too, is peculiar to India, in which country it has been known and dreaded from the most ancient times. Influenza also, which comes at all times and seasons, choleraic in character, and equally mysterious—what is it? These are instances where our science is at fault. That the obnoxious principle lies in paludal poison or marsh miasm, is generally agreed on; but opinions are divided as to the nature of the miasm. One side pronounces it 'a product of vegetable decomposition; the other an exhalation from the earth, favoured by the condition of the marsh.' Others, again, assign the cause to some as yet undiscovered phenomena of telluric chemistry—some aëriform product of decomposition infused into the air immediately above the surface of the earth. But however ignorant we may be of the real causes of zymotic and epidemic diseases, we know that filth, uncleanliness, and an impure atmosphere, are positively favourable to their outbreak and to the virulence of their ravages. The filthy condition of towns in England in former times is scarcely to be imagined: the unpaved streets were made the receptacles for filth and refuse of all descriptions. Cities and towns were thus converted into human jungles not less malarious than the swamps of India. Renewal of air was never regarded as a vital necessity, and fearfully at times was the ignorance punished. In our judicial records will be found more than one mention of a 'black assize.' At Oxford in 1577, three hundred individuals who had attended the court, as well as the judge and sheriff, died from malignant fever within forty-eight hours of the opening of the proceedings. The disease was communicated by the wretched prisoners who had been shut up for months in the noisome cells of an unventilated prison; and a similar instance occurred in London at the Old Bailey in 1756, when the lord mayor, the two judges, besides several persons of note, and many others also, met their death. Cause and effect were never more markedly exhibited. The history of epidemics as regards our own country alone is appalling; the lives swept away in the oft-recurring visitations of the destroyer must be counted by myriads. To go back but two centuries: Howel, writing in 1648, says, 'in and about St Paul's Church horse-dung is a yard deep;' and more than one writer of the days of the second Charles complains that the sulphuretted hydrogen exhaled from the filth and refuse which then defiled the streets of London turned silver black. No wonder that with such a congenial *nidus* prepared for its reception, the pestilence of the East should have ravaged the West. But then, as now, the great plague found its victims among the 'lower orders;' of those in high positions, and among the wealthy, but few comparatively died. Even when no such dread calamity prevailed, the waste of life was startling to a competent observer: Sydenham has left it on record, that in his time from 1000 to 2000 persons died every year in the metropolis of ague and intermittent fever — diseases which seldom occur in the present day except in low, marshy, undrained localities. Had the great plague not been followed by the great fire, London would have suffered again and again from the same causes—want of cleanliness, space, and air. Sir Christopher Wren's noble plan for rebuilding the city, which may even yet be studied with advantage, provided amply for street ventilation; but how imperfectly the benefit was realised, will long remain as a signal instance of shortsightedness and cupidity. Perhaps the sash-windows, which 'came in' with William III., may have assisted in the subsequent gradual ameliorations.

The development of typhus is remarkable: its action is most fatal in northern latitudes; in the south it rarely appears, or very mildly. It is constant in England: jail fever, hospital fever, putrid fever, ship fever, are only other names for the one fell malady—typhus. It is both infectious and contagious; it is not generated in the miasm of churchyards, in the atmosphere of dissecting-rooms, in effluvia from noxious trade-operations, though all these prepare the way for its fatal attacks. It is pre-eminently the disease of the poor and the destitute. Many practitioners who visit exclusively among the wealthier classes never see a case of it. Dirt, privation, bad food, and overcrowding, are powerful predisposing causes; and where these are combined, the contagion plays and riots with human life as the wild winds of the equinox with the fallen leaves of autumnal forests. 'I once went,' states Mr Bowie in his evidence, 'into a room where a woman was lying in typhus fever, a small underground apartment, the window of which opened into a confined area or yard. To this situation she had been confined several days: the window and door were closed; none of the excretions had been removed. On entering the room, I was almost suffocated; the stench was unbearable. I rushed to the window, and threw it open before I could speak a word. After paying my visit, when I got into the street I was seized with headache, giddiness, and sickness. I was so ill the next morning that I was unable to rise, and was confined to bed for several days afterwards. No dead locusts putrefying in a stagnant pool in Ethiopia could have produced a worse smell, or created a more poisonous atmosphere, than existed in that room.' In addition to all other distressing circumstances, the mere pecuniary cost of typhus is an important item in the general sum of suffering. Liverpool expends annually £2400 on cases of typhus fever alone; an amount which, properly applied, would go far towards the entire suppression of the disease. This is a case in which the remedial efficacy of ventilation cannot be too strongly insisted on: it is perhaps the cheapest that can be had recourse to. Varro and Hippocrates knew its value; they both effected cures during the prevalence of epidemics by causing openings for ventilation to be made in the walls of sick-chambers. And there is a passage in one of the letters addressed by Erasmus to Wolsey's physician which would apply with almost equal force at the present day. 'The English,' says the learned Hollander, 'are totally regardless concerning the aspect of their doors and windows to the east, north, and south; then they build their chambers so that they admit not a thorough air, which yet, in Galen's opinion, is very necessary.'

The ancient Romans, with their practical good sense, took measures, extraordinary for the period, to maintain the standard of public health. The first aqueduct for supplying Rome with water was constructed as early as 313 B.C. The huge sewer or *cloaca maxima* is attributed to Tarquin, who also drained the unhealthy swamps which surrounded the seven-hilled city. These swamps are now left to take care of themselves, and the consequence is a perpetual malaria. Roads were gravelled and streets paved by the Romans at an early period, and aediles appointed to have charge over baths, sewers, temples, aqueducts, streets, and roads. At one time during the republic there was a contract by the censors to pay 1000 talents, nearly £200,000, for the repair of the sewers—no mean evidence of the importance attached to the underground channels. The emperors outdid the republic. Agrippa once more repaired the sewers, and turned seven rivers into them with such effect, as to render them navigable. He also built 170 public baths at his own cost. The whole number of these edifices in Rome was nearly 1000. One of them was so spacious, that 3000 bathers could be accommodated at once. Under Augustus the whole city was laid out in *vici* or blocks, each of 230 dwelling-houses; the height of houses was fixed at seventy feet; and the law required that a space of five feet should be left between one house and another; and crooked and narrow streets were straightened and widened.

To turn to another part of the world: when the Spaniards first invaded Peru and Mexico, they were much astonished to find that the 'barbarians,' as they called the natives, were far advanced in those social arrangements commonly considered as inseparable from modern civilisation. Aqueducts, carried 'over hill and valley for several miles,' bore abundant streams wherever luxury or necessity required. The city of Mexico was supplied from a source in a hill a league distant by means of earthen pipes as large as a man's body. There were two rows of pipes, so that if one needed repair, the water could still flow through the other to the capital, there to be distributed to the fountains and reservoirs for the service of the population. And further, as recorded by Mr Prescott:—'A careful police provided for the safety of the city. A thousand persons were said to have been employed daily in watering and sweeping the streets, so that a man—to borrow the language of an old Spaniard—"could walk through them with as little danger of soiling his feet as his hands."' The population numbered 300,000; thus 1 in 300 was employed in the work of cleanliness. If such arrangements—the arts of peace—were made the subject of especial attention by the Romans, and by the barbarians of America, we have the less excuse for neglecting them in our more advanced state of enlightenment.

The visitation of influenza in 1847, and of cholera in 1849, may, if rightly viewed, be taken not only as a warning, but as an index of what has not been done, and of what has to be done. The reports of the General Board of Health published in the latter year embody a large and valuable mass of facts and suggestions on the whole subject in connection with quarantine and the prevention of diseases. With regard to the first of these questions, it appears from the evidence that quarantine regulations, such as have hitherto prevailed, are a mistake, productive more of harm than good; that on the arrival of a ship in port, the immediate removal of the sick to airy quarters provided for their reception on shore is the best means of arresting the progress of disease. Science and philosophy are brought forward in support of these views. 'There has been much confusion of terms,' states the report, 'in respect to the use of the words contagion and non-contagion. We have had instances of professional men who avowed their belief of the contagiousness of typhus, and stated that they had experienced it in their own persons. When asked for the evidence on which the belief was founded, they have usually related some circumstances showing, not the contagiousness, but the infectiousness of the disease. Contagion is a term applicable to a different set of circumstances. According to the hypothesis of contagion, no matter how pure the air, no matter what the condition of the fever ward, if the physician only feels the pulse of the patient, or touches him with the sleeve of his coat, though he may not catch the disease himself, he may communicate it by a shake of the hand to the next friend he meets. If this were so, the track of a general practitioner who attended one patient labouring under a specific epidemic disease would be marked by the seizure of the rest of his patients; and if any disease of common occurrence really possessed such powers of communication and diffusion, it is difficult to conceive how it is that the human race has not been long since extinguished. It is not in human power to take from any disease the property of contagion, if this property really belong to it; but it is in our power to guard against and prevent the effects of any contagion, however intense; and it is equally in our power to avoid communicating to common disease an infectious character, and aggravating it into pestilence. Strictly, contagion, as the word implies, is capable of being communicated only by actual contact; while the influence of infection, as far at least as regards the diffusion of the exhalations of the sick into the surrounding atmosphere, is represented to be limited to the distance of a very few yards.'

It may not be uninteresting to follow what is here advanced concerning contagion with some particulars as to the genesis and development of cholera, as communicated by Dr S. Davis of Patna to the Statistical Society:—'During the eight years,' he observes, 'of my residence here, I have seen several severe visitations of cholera and remittent fever, the former usually making its appearance at the commencement of the hot winds. There is often in April and May an indescribable but well-understood state of the atmosphere, accompanied with variations in the wind, and a hazy and sultry appearance, that is favourable to the production of the former very frightful disease. During such weather you find vegetation blighted by impalpably small animalculæ, which elude the perception of the naked eye, but are easily discovered by the aid of the microscope. I have long thought that cholera, and some other diseases, have their origin in animalculine blight; and late writers have brought together so many facts bearing on the subject, that this opinion gains ground with me daily; nor is the circumstance of diseases spreading more in crowded cities than in smaller localities at all contrary to this theory, since there are so many more points of attraction and deposit. The state of the atmosphere is without doubt greatly modified by the locality over which it ranges; and in situations favourable to the production of disease, it is not unreasonable to conclude that a peculiar state of it is attended by a vivifying influence which brings into existence poisonous animalculine exhalations capable of producing maladies in those who may be obnoxious to it, either from congenital or induced debility, or other idiosyncrasy.'

The enumeration of evils in many instances serves to suggest the remedies. If it be objected that we have left too little space for the discussion of the latter, we should find a sufficient answer in the fact, that more than one responsible 'board' or 'commission' is at work on the whole subject. Our summary of the recommendations embodied in the Health of Towns' Report for 1845 will already have conveyed an idea of the essential points; and a brief abstract of the several acts of parliament, all more or less consequent on the general sanitary inquiry, may appropriately serve to complete the scheme. We shall take them chronologically. An act passed in August 1844, to take effect in January 1845: it regulates and prescribes the height of houses in proportion to the width of streets; the dimensions of courts and backyards of dwelling-houses, so as to insure free access of air for ventilation. It provides for duly-proportioned windows, without providing for the repeal of that egregious legislatorial blunder which perpetuates a window-tax. Dangerous trades or occupations are to be carried on at a distance of forty feet from any house; and those offensive or noxious—blood, bone, tripe, or soap-boiling, fell-mongering, tallow-melting, slaughtering of animals—are not to be within less than fifty feet of any dwelling, or forty feet of any public way. And further, in thirty years from the date of the act, 'it shall cease to be lawful to continue to carry on such business in such situation.' This enactment, however, contains a saving clause, to be applied in special cases. The act also embodied a clause prohibiting the use of cellars as dwellings under certain conditions. Those persons who live in London will remember how the builders started into unwonted activity towards the close of 1844; houses were built or commenced on every spare spot of ground, whether suited to the purpose or not; and the result is, that several of the leading thoroughfares, especially on the 'Surrey side,' are completely spoiled by unsightly projections, whose form is anything but that which constitutes a convenient dwelling. It is not presumptuous to predict that the buildings thus erected by over-hasty enterprise will some day have to fall before the sanitary reformer. Liberty of the subject is a great privilege, but not to be tolerated when it prejudices the common-weal.

The act to encourage the establishment of public baths and washhouses was passed in August 1846. On requisition of any ten rate-payers a vestry meeting may be convoked, at which two-thirds of the number present may decide to erect baths and washhouses, and charge the cost on the poor-rate. The resolution is to be sent to the Secretary of State, and the arrangements to be under the supervision of government commissioners. A code of by-laws is also enacted, to be observed in such establishments for the proper maintenance of order, decency, and economy. In June of 1847 came an act for consolidating the provisions for lighting, cleansing, and improving towns. It provides for the appointment of surveyors and inspectors of nuisances; for plans of districts, or places where pipes or drains are to be laid, to be drawn and engraved on a scale of sixty inches to the mile; for the management, alteration, and construction of sewers; no unauthorised drains to exist under penalty of £20. The commissioners are empowered to drain houses or buildings, to construct ash-pits and privies, and recover the cost from any proprietor refusing to comply with the regulations. Cesspools and drains may at all times, after notice given, be viewed by the inspector. The paving of streets to be also subject to the same control. No new streets to be laid out without authority, and to be not less than thirty feet wide if a carriage-way, or twenty feet if not a carriage-way. Streets to be named and numbered; gates to open inwards; projections to be removed; and, where a wider thoroughfare is required, houses, when rebuilt, to be set back; the fixing of water-spouts, erection of public clocks, and licensing of slaughter-houses, also to come under the same authority. With the proviso of four weeks' special notice, 'the commissioners may purchase, hire, or build slaughter-houses and knackers'-yards—places for public recreation—and public bathing-places, washhouses, and drying-grounds; but in any building provided for baths, the number of baths for the working-people must not be less than double that for the higher classes.'

Another act for promoting the public health passed in August 1848. It applies to all parts of England and Wales, except some metropolitan districts, and provides for sanitary improvements. One-tenth of the poor-rate payers in any town may petition for an inspector to visit and report on the state of the locality; or, if on an average of seven years, the Registrar-General finds the deaths to exceed 23 in 1000, the Central Board may then, on their own responsibility, send down an inspector, and issue a provisional order according to circumstances. Vaults, cellars, or drains, must be made according to fixed regulations; no house to be built or repaired below the ground-floor without proper covered drains communicating with a sewer, or without ash-pits and privies; the latter conveniences, especially, to be provided at workshops where above twenty of both sexes are employed at the same time, under a penalty of £20, or £2 a day on default. Lodging-houses are to be registered and limited as to number of inmates; cellar dwellings are prohibited unless seven feet high, three feet being above the street, and properly drained, and provided with all essential conveniences. Nuisances may be summarily abated, and overcrowded vaults and burial-grounds may be closed when necessary. The act further confers powers on local authorities, and prescribes penalties. The whole of the provisions were further confirmed and extended by additional acts passed in 1849.

What more is wanted? is a question that naturally arises after perusing the legislatorial enactments. Herein are embodied all the essentials of efficient sanitation. But opposition is strong, whether based in selfishness or ignorance; and 'the greatest good of the greatest number' must be conquered inch by inch from shortsighted opponents. Opposition was offered to Philip Augustus when he wished to pave the miry streets of Paris; the parliament of the Protectorate were opposed in their measures for getting rid of brick-kilns within the precincts of London; and who is there that will not remember instances of opposition to sanitary improvement within his own experience? The assault has, however, been made, and although the advances are lamentably slow, eventual success must be achieved. Besides the Commissions mentioned more than once in the course of the present Paper, and the General Board of Health, there is the New Sewers' Commission. Talent and ability are not lacking, and the sooner these qualities are manifested in real practical efforts the better for all parties. If the plans for the sewerage and drainage of London be not yet matured, we see no reason why the surface of the streets should not be properly cleansed. The withdrawal of the opposition to the general introduction of Mr Whitworth's street-sweeping machine would be an important step in the right direction, and tend greatly to promote individual cleanliness. Whatever system of drainage may be adopted for the metropolis, we for our part should like to see it combined with Mr Martin's plan for diverting all the sewerage from the river, and constructing a broad public terrace-thoroughfare on each side from Vauxhall to London Bridge, whereby a good view of the noble stream would be obtained, as well as an airy promenade for the pent-up citizens. We would not have water, taken from the Thames in or near London, drunk on any terms; but we would have the river saved from its present overwhelming pollution—a measure the more necessary, when it is considered that the surface of the stream within the limits of the metropolis is 2245 acres. The fouler the water, the more noxious the exhalations—a fact which hitherto has not received all the attention it deserves.

If our remarks throughout have been more especially applied to London, it is that we hope to see the capital city become a model for the whole kingdom: she may, however, take lessons from without as well as within. In some instances we are indebted to cholera for ameliorations which ought to have resulted from foresight. Since the visitation of the epidemic, Birmingham has been favoured with a 'constant supply' of water, to the great comfort and convenience of the inhabitants, many of whom now dispense with the encumbering and insalubrious water-butt. The 'toy-shop' town, too, is well swept; not a court or alley but is purged by the scavenger's broom at least once a week, while in the leading thoroughfares no accumulations of dirt are permitted.

How much is involved in the great question which we have here endeavoured to discuss in a practical and philosophical spirit! All human interests are in some way concerned. Legislative policy, political economy, the amenities of civilisation, are unsound and imperfect, unless based on true social economy. Education without sanitation must be *ex necessitate rei*—inefficient and unsatisfactory: it is not easy to elevate minds familiarised with filth and squalor. There is an essential dependence between physical and moral purity. If the substratum of society is to be uplifted, perhaps no means would be so permanent and effectual as its sudden introduction into an improved class of dwellings. A great point is gained when people become sensible that a degree of responsibility rests upon them—that they have a character to lose. And to this point—unless experience be fallacious—we can only arrive by means of the combined ameliorating influences of sanitation and education.

There is much in the question to task and interest the restless spirit of invention and enterprise, which now, as ever, characterises the British people. The meteorologist, by his studies on climate and temperature, may render valuable service to the physician in framing an extended code of laws of health. The mechanician, the engineer, the artisan, will here find scope for their highest ingenuity: we want the simplest and best modes of building, of fitting interiors, of constructing streets, of warming, lighting, and ventilating. All these are prime desiderata, waiting their realisation in some coming Newton of sociology. All human sympathies may find exercise in the work. It is better to train and lead than to punish; better to coerce by moral than mechanical influences. Reputation, too, is to be won, and 'glory' achieved, in this aggressive movement, not less brilliant and far more lasting than that won by cannon and cohorts. Happily our hands are less fettered than formerly: to some extent we can

'Cut Prejudice against the grain:'

we have outlived the notion, that the calamitous results of human error and social ignorance are the direct and inevitable inflictions of Providence, to be submitted to with Mohammedan fatality. The philosophy of cause and effect has cleared the question of most of its difficulties; and we can but trust that far-reaching views will be combined in its solution with soundness of judgment and promptitude of action, and that a liberal spirit will animate all parties in the furtherance of so grand and benevolent a work.

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